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Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

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Potential Techniques of Interactive Packaging in Cardboard Carton and Their Effect on Overall Quality Characteristics Such as Sugars, Colour, Texture, Taste and Flavour of Chaunsa White Variety of Mango at Ambient Temperature During Storage

Habib Ahmed Rathore[1], Tariq Masud[2], Ahmad Raza[2] and Muhammad Rizwan[2]
[1]Department of Food Technology, University College of Agriculture, Rawalakot, AJK
[2]Department of Food Technology, University of Arid Agriculture, Rawalpindi, Pakistan

Abstract: Potential techniques of Interactive Packaging in Cardboard Carton (IPCC) had significant effect ($p<0.05$) effect on overall quality characteristics such as Reducing Sugar (RS), Total Inert Sugar (TIS), Sucrose (SUC), Total Sugar (TS), Sugar Acid Ratio (SAR), Skin Colour (SKC), Flesh Colour (FLC), Texture (TEX), Taste (TAS) and Flavour (FLA) of Chaunsa white variety of Mango at ambient temperature (28-33^{0}C and 56.7-69.7% relative humidity) during storage. It was determined that using of potential techniques of coating emulsions having fungicide, ethylene absorbent and anti-ripening agent for (IPCC) technology showed higher contents of RS ranged from (10.14-11.58%), lower TIS (20.05-24.58%, except carton having 29.58%), SUC (9.19-18.34%), TS (19.57-22.53%) and SAR (22.63-86.27) with an average mean of 10.73%, 24.12%, 13.68%, 24.75% and 46.10 respectively. Whereas, the higher scores of organoleptic characteristics such as SKC score ranged from (4.09-5.01), FLC (4.01-5.02), TEX (4.48-5.27), TAS (3.81-5.20) and FLA (4.05-4.69) with an average mean of 4.53, 4.47, 5.03, 4.48 and 4.38 score respectively was observed in IPCC system up to end of storage. On the other hand the control sample (T1) comparatively had lower RS (9.66%), higher TIS (28.51%) except carton with highest percent (29.58%), highest SUC (19.83%), TS (29.38%), SAR (103.6), SKC score (5.82), FLC (4.55), TEX (4.98), TAS (4.67) and FLA score (4.81) respectively at earlier stage of storage. The present studies show that IPCC system having with other protective chemicals had a vital role in delaying the ripening process of mango fruit and extended storage life up to 25 days with minimum quality loss as compared to Control sample due to its unattractive skin, brown pulp color and poor taste was unacceptable after 12 days of their storage and had greater compositional changes with maximum quality loss during storage.

Key words: Fruit, Chaunsa mango, interactive packaging, sugars, organoleptic, physico-chemical composition

INTRODUCTION

Potential techniques of Interactive packaging such as pre-cooling/ hot water treatments, use of antimicrobial agents, skin coatings prior to packaging, inducing or enhancing ripening agents and reducing or delaying ripening agents in the package are playing an important role in post harvest management of fruits and vegetables by delaying the ripening process and longer retention of quality pretreatments of fresh produce (John, 2008). Mango is subtropical and climacteric fruit that normally reach to maturity in 4-5 month depending on variety and environmental conditions, fruit takes 6-10 days to ripen under ambient temperature and become over-ripe and spoiled within 15 days. A series of biochemical changes such as degradation of chlorophyll, biosynthesis of carotenoids, anthocyanins, essential oils and flavour components, increase the activity of cell wall degrading enzymes are initiated by the autocatalytic production of ethylene and increase in respiration that causes physiological, biochemical and organoleptic changes results in characteristic color, taste, aroma with desirable softening (Tharanathan *et al*., 2006). In a recent study, it was reported that pre-treatments and polyethylene packaging had significant effect on overall chemical constituents such as sugars and organoleptic parameters and it was noted that the coated fruit packed in polyethylene had longer shelf life, minimum quality loss and slower increase in sugars (RS, TIS, SUC, TS) contents and lower score of colour, taste or higher texture and slower increase of flavour score of chaunsa due to slow process of ripening white variety of mango during storage (Rathore *et al*., 2009). In an other study fruit stored in wax- lined cartons sealed with chitosain films had a longer shelf life and retained a higher level of desirable quality attributes than fruits stored in wax-lined carton sealed with LDPE films or in

Corresponding Author: Habib Ahmed Rathore, Department of Food Technology, University College of Agriculture, Rawalakot, AJK

perforated plastic boxes (Srinivasa *et al*., 2004). In India banana and mango treated with polysaccharide bases coating formulations of starch, Carboxymethyl cellulose, or chitosan, blended with a suitable lipid and wetting agent had retarded color development, lower acidity, greater firmness values, reduced in weight loss and CO_2 evolution. It was also noted that Chitosan based coating were much superior in prolonging the shelf life and quality of mango (Kittur *et al*., 2001). The waxes coating, oils and similar materials also reduce evaporation of water and exchange of respiratory gases (CO_2 and O_2) by adding natural resistance of skin and also directly improve the appearance of fruit. Koolpluksee *et al*. (1993) packaged Nam Dok Mai mango in Polyethylene (PE) or Polypropylene (PP) bags, perforated (8 pinholes/bag) or not perforated and with or without ethylene absorbent (EA) were stored at 10°C and 90-93% RH. Storage treatments reduced off-odours, off-flavours and Chilling Injury (CI) and delayed ripening compared with control fruits (stored in plastic buckets). Post harvest application of $CaCl_2$ indicated slightly delay in ripening, extended storage life by a week and lower rate of fresh weight loss in treated Haden mango, stored at 15°C with 90% RH (Zambrano and Manzano, 1995). Life of the fruit and maintenance of their quality through Modified Atmosphere Packaging (MAP) is possible, that depends on types and properties of packaging/fruit, concentration of gases (Srinivasa *et al*., 2002; Sarkar *et al*., 1997; Koolpluksee *et al*., 1993; Yantarasri *et al*., 1994), temperature and Storage treatments (Rana *et al*., 1992; Clarke *et al*., 1997), grading of fruit and size of fruit (Singh *et al*., 1989). The above-mentioned literature shows that coating, modified atmosphere, fungicide or ethylene absorbent had increased the storage life or quality of fruit during storage. Moreover, literature is silent about the potential techniques of interactive packaging in cardboard carton and their effect on overall quality characteristics such as reducing-non reducing and total sugars, sugar acid ratio, colour, texture, taste and flavour of chaunsa white variety of mango at ambient temperature during storage. Therefore, the aim of the present study was to evaluate the effect of potential techniques of Interactive Packaging in Cardboard Carton (IPCC) on overall chemical constituents such as sugars (RS, TIS, SUC, TS and SAR) and other organoleptic parameters like; color, texture, taste and flavour (SKC, FLC, TEX, TAS and FLA) of chaunsa white an important commercial variety of mango at ambient temperature during storage.

MATERIALS AND METHODS

Collection of sample, pretreatments and storage: Fresh arrival of un-ripened, matured, hard green and uniform size of Chaunsa white which is very important commercial variety of mango was purchased from wholesale fruit market at Islamabad and immediately transferred to post harvest laboratory of Department of Food Technology in University of Arid Agriculture Rawalpindi. After careful sorting, fruits in cotton bags were subjected to hot water treatment at 53°C for three minutes and immediately cooled by dipping in cold water at 20°C and were dried in air. Coatings were prepared according to the concentrations as described by Rathore *et al*. (2009). Fruit was graded according to their size and total 180 selected fruit were divided into 6 groups having 30 mangoes in each group respectively. These groups were under gone into following 6 treatments viz; Control (T1), Carton (T2), Wax-CMC having NaOCl coated fruit packed in Carton (T3), Wax-CMC Coated fruit with $KMnO_4$ package in Carton (T4), Wax-CMC Coating having 2,4,5-T in Carton (T5), H_3BO_3 and 2,4,5-T having oil treated fruit packed in Carton (T6) and then were stored at ambient temperature (28-33°C and 56.7-69.7% relative humidity) for a storage period of 30 days.

Physico-chemical and sensory evaluations: Physico-Chemical parameters such as reducing and non-reducing sugars were determined by Lane and Eynon method according to standard procedures as mentioned in AOAC (1990). The sensory evaluation of treated and untreated fruit were made by using hedonic 9 point scale for different characteristics such as peel color, flesh color, texture, taste and flavor by panel of trained Judges according to methods reported by Larmond (1977). The data obtained were statistically analyzed for Analysis of Variance (ANOVA) by using 2-Factorial Complete Randomized Design (CRD) and Duncan's Multiple Range Test (DMRT) was applied to compare the mean values obtained according to the method described by Steel and Torrie (1980).

RESULTS AND DISCUSSION

It was investigated that Chaunsa white variety of mango uncoated fruit or coated fruit packed in carton had affected the overall quality characteristics such as sugars, colour, texture, taste and flavour of chaunsa white variety of mango at ambient temperature during storage.

Reducing sugar: The Table 1 presents that treatments and their interactions had highly significant effect on percent reducing sugar of mango during storage and the percent reducing sugar in coated fruit packaged in carton was 10.14-11.58% with an average means of 10.73% during 25 days of storage at ambient temperature compared to first day with very low percent reducing sugar (5.95 %). therefore, with the fluctuations showing an increasing trend of percent reducing sugar during storage. The increase in Reducing Sugar (RS) level could be attributed mainly due to breakdown of starch into water soluble sugars, sucrose and glucose during ripening along with a proportional increase in RS level and further hydrolysis decreased the RS during storage. Srinivasa *et al*. (2002) and Kittur *et al*. (2001) have expressed similar views. It is evident from Table 1 that statistically there was a significant effect of all treatments on percent reducing sugar except T2 and T4 (10.14, 10.32) or T5 and T6 (10.44, 10.59) an insignificant difference in between treatments was noted, however these groups of treatments were significantly different from others treatments. The maximum percent reducing sugar was observed in T3 (11.58%) followed by T6 (10.59%), T5 (10.44 %), T4 (10.32 %) and T2 (10.14 %), respectively as compared to control T1 (9.67%) had lower percent reducing sugar than T3 (11.58%), however, the control showed lower content reducing sugar than other treatments during storage or at first day with minimum content reducing sugar (5.95%) at ambient temperature during storage. These results revealed that RS contents were higher in packaging either in polyethylene (T2), or the combination as poly-coat might be due to controlled or modified atmosphere showed better development of RS at later stage on 18^{th} day as compared to control. It was also observed that addition of Wax-CMC coating having ethylene absorbent or antiripening agent in T5, T6 and T7 in polyethylene had lower RS contents as compared to packing in polyethylene or control. Furthermore, these treatment also reached to maximum RS at later stage on 18^{th} day might be due to combination of coating with packing produced better environment that reduced metabolic process that caused a slow down in conversion of starch to simple sugars during storage. These results are correlated with the findings of Srinivasa *et al*. (2002). Kittur *et al*. (2001) also reported that mango and banana treated with polysaccharide-based coatings had lower reducing sugar contents than control at ambient temperature (27±2°C and 65% RH, suggesting that the former synthesized reducing sugar at lower rate than control during storage.

Total invert sugar: The Table 1 indicates that treatments and their interactions had highly significant effect on percent invert sugar of late Chaunsa white mango at ambient temperature during storage. the percent total invert sugar in coated fruit packaged in carton was 20.05-29.58% with an average means of 24.12% in coated fruit packaged in polyethylene as compared to control having maximum total invert sugar percent (28.51%) after 25 days of storage at ambient temperature or at first day with very low total invert sugar percent (8.38%) at ambient temperature during storage. Therefore, with the fluctuations percent total invert sugar showing an increasing trend during storage. The increase in percent total invert sugar level could be attributed mainly due to breakdown of starch into water soluble sugars, sucrose, glucose and fructose during ripening as a result, a proportional increased in percent total invert sugar level and further hydrolysis decreased the percent total invert sugar during storage. It is obvious from Table 1 that statistically a significant difference of percent total invert sugar among all treatments was found during 18 days of their storage and the maximum percent total invert sugar of late Chaunsa white mango were observed in T2 (29.58%), followed by T4 (26.70%), T3 (25.14%) T6 (24.58%) and T5 (20.05%) as compared to control having maximum total invert sugar percent (28.51%) after 25 days of storage at ambient temperature or compared to first day having minimum total invert sugar percent (8.38%) in Chaunsa white mango. It was observed that ripening process was faster in control (T1); however the combination of poly-coat packaging had reduced the ripening process. The efficiency of polyethylene packaging was improved further, by coating the fruit with Wax-CMC having fungicide, ethylene absorbent or antiripening agent in T3, T4, T5 and T6 only packed in polyethylene might be due to reduction in metabolic activities by modified atmosphere produced by treatments during storage.

Sucrose: The Table 1 indicates that treatments and their interactions had highly significant effect on percent sucrose content of late Chaunsa white mango at ambient temperature during storage. the percent sucrose sugar in coated fruit packaged in poly-carton was 9.19-18.34% with an average means of 13.68% after 25 days of storage at ambient temperature as compared to control with maximum percent sucrose content T1 (19.83%) or at first day with very low percent sucrose content (2.26%) at ambient temperature during storage. The increase in percent sucrose sugar level could be attributed mainly due to breakdown of starch into water soluble sugars sucrose, glucose and fructose during ripening along with a proportional increase in percent sucrose sugar level and further hydrolysis decreased the percent sucrose sugar during storage. Similar results are reported by Kittur *et al*. (2001). It is obvious from Table 1 that statistically a significant difference of percent sucrose content among all treatments was found during storage. The maximum percent sucrose content of late Chaunsa white mango were observed in T2 (18.34%), followed by T4 (16.60%), T6 (15.99%), T3 (12.94%) and T5 (9.19%), however, these treatments maintained sucrose of mango at lower level as compared to control with maximum percent sucrose content T1 (19.83%) at ambient temperature during storage. These investigations show that control sample had higher sucrose content than polyethylene, however, the sucrose content was further reduced when fruit were packaged in poly-Wax-CMC polysaccharide based coatings having fungicide, ethylene absorbent or antiripening agent combinations in T3, T4, T5 and T6 respectively with minimum sucrose content might be due to reduction in metabolic activities by a modified atmosphere produced by combinations of coating with these packaging materials. These results are in line with those of Kittur *et al.* (2001) who reported that polysaccharide-based coating of mango and banana had lower reducing sugar content at ambient temperature (27±2°C and 65% RH had lower reducing sugar content and TSS in polysaccharide-based coated fruits as compared to control.

Total sugar: The Table 1 reveals that treatments and their interactions had highly significant effect on total sugar percent of late Chaunsa white mango during storage and the percent total sugars in coated fruit packaged in carton were 19.57-28.53% with an average means of 24.75% in treated fruit packaged in polyethylene as compared to control with maximum total sugar percent T1 (29.38%) after 25 days of storage at ambient temperature or at first day with very low total sugar percent (8.21%). The increase in percent total sugar level could be attributed mainly due to breakdown of starch into simple sugars during ripening along with a proportional increase in percent total sugars level which was attributed to the increased activity of amylase and other enzymes resulting in gluconeogenesis and converted into sucrose, glucose and fructose during storage. Further hydrolysis decreased the level during storage. These results are correlated with the findings of Srinivasa *et al.* (2002); Kudachikar *et al.* (2001). It is obvious from Table 1 that statistically a significant difference of total sugar percent in all treatments except T4 (26.6%) and T6 (26.59%) an insignificant effect was found during 25 days of their storage. The maximum total sugar percent of late Chaunsa white mango were observed in T2 (28.53%), followed by T6 (26.59%), T4 (26.60%), T3 (24.34%) and T5 (19.57%) however, these treatments having comparatively lower percent sucrose content as compared to control with maximum total sugar percent T1 (29.38%) or at first day with very low total sugar percent (8.21%) at ambient temperature during storage. These results are correlated with the findings of (Srinivasa *et al.*, 2002) who reported that Alphonso mango treated with Carbendazim fungicide had an increasing trend of total sugar from 23.00-150 mg/g in control sample on 12th day and then spoiled, whereas, low-density polyethylene (100 gauge LDPE) top covered carton boxes fruit gave the maximum values on 16th day at ambient temperature 27±1°C at 65% RH respectively.

Sugar acid ratio: The Table 1 presents that treatments and their interactions had highly significant effect on sugar acid ratio of mango during storage. the sugar acid ratio in coated fruit packaged in carton was 22.63-86.27 with an average means of 46.10 in coat-carton combination as compared to control with maximum sugar acid ratio T1 (103.6 %) after 25 days of storage at ambient temperature or at first day with very low sugar acid ratio (8.21%). The increase in sugar acid ratio level could be attributed mainly due to breakdown of starch into water soluble sugars, sucrose and glucose during ripening along with a proportional increase in sugar acid ratio level and further hydrolysis decreased the sugar acid ratio during storage. It is obvious from Table 1 that statistically there was a significant difference of sugar acid ratio among all treatments except T3 and T6 (44.55%, 55.09%) or T4 and T6 (61.12%, 55.09%) during 25 days of their storage. The maximum sugar acid ratio of late Chaunsa white mango were observed in T2 (86.27%), followed by T4 (61.12%), T6 (55.09%), T3 (45.55%) and T5 (22.63%) however, these treatments having comparatively lower sugar acid ratio as compared to control with maximum sugar acid ratio T1 (103.6%) or at first day with very low sugar acid ratio (8.21%) at ambient temperature during storage. Manzano *et al.* (1997) observed similar decreasing trend in Hadden mango treated with waxes coating stored at different temperatures had significantly decreasing trend of TSS acid ratio from 170.24-37.50 during 20 days of their storage. TSS acid ratio value (98.74) was higher in ethylene treated as compared to no treated fruit. These results are coincide with those Ladaniya and Sonkar (1997) who observed a maximum retention of total soluble solids and acid ratio, flavor and shine in Nagpur mandrine (Citrus reticulata) in waxed treated fruit with 2000 ppm Carbendazim fungicide, packaged in ventilated corrugated fiber-board boxes lined with polyethylene during 21 days of storage at ambient temperature. The change in total soluble solids and acid ratio did not indicate any trend with respect to treatments, although the ratio declined slightly during storage. The least ratio (17.24) was found in mechanically waxed fruit packed without polyethylene. No effect on percent acidity and brix level indicates that respiration rate was unaffected in waxed treated fruit.

Skin color: The Table 2 illustrates that treatments and their interactions had highly significant effect on skin color score of mango during storage. the skin color score in coated fruit packaged in poly-carton was 4.09-5.01 with an average means of 4.53 in coat-carton combination as compared to controlled with maximum skin color score T1 (5.82) during 25 days of storage at ambient temperature or as compared to first day having minimum skin color score (3.00). The loss of green color was the most obvious change in mango, which was probably due to the physico-chemical changes by degradation of the chlorophyll structure and increased in carotenoid pigments during storage. The principal agents responsible for this degradation might be the oxidative system, pH change and enzymes like chlorophyllases (Wills *et al.*, 1982; Doreyappy-Gowda and Huddar, 2001). It is obvious from Table 2 that statistically there was a significant effect of treatment on SKC score except T2 and T4 (4.80, 4.73) having an insignificant difference, however a significantly different SKC score among the treatments of one group to the treatments of other group was found during 25 days of their storage.

The maximum skin color score of late Chaunsa white mango were observed in T3 (5.01), followed by T2 (4.80), T4 (4.73), T5 (4.31) and T6 (4.09) as compared to control with maximum skin color score T1 (5.82) during 25 days of storage at ambient temperature. Similarities in skin color score among the treatments including control that might be due to the hot water treatment given to all fruit at initial stage raised the temperature that caused an increase in SKC for movement however, due to high temperature enzymes were inactivated, therefore control also retained a higher skin color up to 15th day. On the other hand Wax-CMC coated fruit had slow down the metabolism with higher skin color retention during storage as compared to control that might be due to variation in modified atmosphere created by different types of treatments delay in chlorophyll degradation and slower rate of synthesis of anthocynanine or carotenoids in modified atmosphere (Kittur *et al*., 2001; Carrillo-Lopez *et al*., 2000; Manzano *et al*., 1997). Ethylene absorbents or removers in poly-coat packaged had lower sensory score as compared to control might be due to the slower metabolic activities because of removal of produced ethylene, a catalyst for ripening and also had higher SKC retention might be due to increased CO_2 and reduced level of O_2 in MAP which reduce respiration rates and delay ripening, that is confirmed by other workers (Rodov *et al*., 1997; Srinivasa *et al*., 2002). Raje *et al*. (1997) in India also reported that the alphonso mangoes treated with different types of ethylene inhibitors including $KMnO_4$ showed higher sensory score at 16th day as compared to control on 8th day at 32-36°C and RH of 70-75% and then spoiled. Rosa *et al*. (2001) in Isreal reported that $KMnO_4$ in MAP with polyethylene wrapped Tommy Atkin or Keitt cultivars of mangoes delayed ripening as expressed by less color development and ethylene absorption inhibited chlorophyll breakdown at 12 or 8°C for 3 weeks plus 5 days shelf at 20°C with out MAP. The main factors that retain mango quality in MAP are increased CO_2 levels and decreased O_2 levels which reduce respiration rates and delay ripening. The delay in ripening, degradation of chlorophyll and retention of green color for a longer period also depend on types of coating (Manzano *et al*., 1997; Kittur *et al*., 2001), hot water treatment before storage (Opara *et al*., 2000; Mortuza and Reza, 2001), coating concentrations and temperature during storage (Carrillo-Lopez *et al*., 2000; Makil and Sing, 2003). The results of the present studies show that increase in quality and availability of fruit with maximum skin color for a longer period in treated fruit is very encouraging. Coating of Chaunsa white packaged in only polyethylene (T2), coating having fungicide in Polyethylene (T3), coating with ethylene absorbent in polyethylene (T4), coating with antiripening agent in polyethylene (T5), coating with antiripening agent with oil and disinfectant in polyethylene (T6) had slower increase in color score due to slow ripening process may be very effective in delay ripening process with minimum skin color score during storage.

Flesh color: The Table 2 indicates that treatments and their interactions had highly significant effect on flesh color score of mango during storage. The skin color score in coated fruit packaged in poly-carton was 4.01-5.02 with an average means of 4.47 in poly-coating combinations as compared to control T1 (4.56%) with maximum flesh score during 25 days of storage at ambient temperature or at first day with minimum flesh color score (2.5). It was observed that in general the skin color score had increasing trend first and then significant decreased of skin color score during storage. During storage mangoes made the transition from green to yellow, which was due to degradation of chlorophyll indicating an increased acceptability for consumption. This change might be mediated through the action of enzyme chlorophyllase, enzymatic oxidation and or photo degradation. It is obvious from Table 2 that statistically there was a significant effect of all the treatments on flesh color score except T2 or T4 (4.70, 4.79) or T5 or T6 (4.01, 4.05) having an insignificant difference was observed during 25 days of their storage. The maximum flesh color score of late Chaunsa white mango were observed in T3 (5.02), followed y T4 (4.79), T2 (4.70), T6 (4.05) and T5 (4.01) and having comparatively lower flesh color score than controlled T1 (4.56 or at first day with minimum flesh color score (2.5) at ambient temperature during storage. Carrillo-Lopez *et al*. (2000) also stated that Haden mangoes coated with different concentrations of Semper fresh had higher retention of green color as compared to noncoated fruit at 13°C during 32 days storage. Manzano *et al*. (1997) evaluated the effect of coatings on color development in Hadden mango and reported that mango treated with waxes coating had lower color values and retention of color also depend on types of coating is confirmed with our studies however, did not agree with that the control having higher color score than treated fruit might be lacked of hot water treatment in the research of others. Where as in our studies T2, T4 and T5 had no significant difference in FLC with control (T1) might be due to higher temperature of hot water treated fruit at initial stage caused an increase in carotenoids of flesh of fruit and later stage maintained carotenoids might be due to inactivation of enzymes. However after 12th day of storage due to over ripening control fruit could not maintained flesh color as compared to T2, T3, T4 and T8 maintained higher FLC up to end of storage might be due to due to inactivation of enzymes and modified atmosphere slower process of changes in chlorophyll. These results are in line with Opara *et al.* (2000) who reported that hot water treatment at 52°C had higher pulp color score (4.5) as compared to control (3.4%) that was also depending on time of exposure and higher color was noted at 10 min than for 5 min of hot water treatment. Chaunsa white mango coated with WAX-CMC having some chemicals restricted the changes and formation of carotenoids were depressed might be due to the slow down of metabolic activities in T2, T3, T4 and T8 by the combined action of NaOCl, $KMnO_4$ and 2,4,5-T respectively. The chemical reactions are going side by side in both of SKC and FLC; however, comparatively higher score of FLC shows that changes were rapid in pulp than peel in these same treatments. The lower values of FLC in T3 and T8 show that $KMnO_4$ or 2,4,5-T with NaOCl that ripening process was slower in these treatments might be due to lower concentration of ethylene in surrounding atmosphere. These results are an agreement with those of Raje *et al.* (1997) in India reported that the alphonso mangoes treated with different types of ethylene inhibitors including $KMnO_4$ showed higher sensory score at 16th day as compared to control on 8th day at 32-36°C and RH of 70-75% and then spoiled.

Texture: The Table 2 reveals that treatments and their interactions had highly significant effect on TEX score of mango during storage. The TEX score in coated fruit packaged in poly-carton was 4.48-5.27 with an average means of 5.03 in coated fruit packaged in polyethylene combinations as compared to control with minimum TEX score T1 (4.98) during 25 days of storage at ambient temperature or at first day with very low TEX score (4.00) at first day with very low TEX score (4.00). Therefore, showing an increasing trend of texture in all treated fruits. The reduction of texture during storage that might be due to the breakdown of insoluble pectic substances to soluble forms and these pectin polymers became less tightly bound in the cell walls during ripening. The declining concentration of calcium might reduce calcium pectin interaction, allowing free release into flesh leading to reduce firmness as the fruit ripen, resulting in shriveling of over-ripe mango fruits, as discussed earlier. It is obvious from Table 1 that statistically there was a significant effect of treatment on TEX score in all treatments except T1, T3, T4 and T5 (4.98, 4.90, 4.97 and 4.99), an insignificant effect in between treatments was observed. However these treatments were significantly different to others during 25 days of their storage. The maximum TEX score of late Chaunsa white mango were observed in T6 (5.27), followed by T5 (4.99), T4 (4.97), T3 (4.90) and T2 (4.48) as compared to control with minimum TEX score T1 (4.98) or at first day with very low TEX score (4.00) at ambient temperature during storage. All of the treatments had delayed in the degradation of pectic substances and improved the TEX score of fruit, however the those treatments with WAX-CMC coating with $KMnO_4$ and 2,4,5-T in T4 and T5 respectively were more effective to retain higher texture of fruit at later stage on 25 days might be due to the difference in types of coating which caused a variation in increased CO_2 and decreased O_2 levels of modified atmosphere. These treatments reduced respiration rates and the activities of enzymes more effectively and lower metabolic activities or slower biochemical changes in modified as compared to $CaCl_2$ with the same chemicals in T5, T6 and T7 were over ripen with worse conditions of TEX. Moreover, the combination of $CaCl_2$ with WAX-CMC in T8 was more effective to retain higher TEX score up to end of storage. These investigations are correlated with Kittur *et al.* (2001) who recorded that banana and mango with carboxymethyle cellulose or other polysaccharide based coatings had higher firmness and delaying in the ripening at ambient temperature (27±2°C and 65% RH). Polysaccharide-based coating formulations had slower metabolism due to the reduced activities of pectic enzymes such as amylases, starch phosphorylase and α-1, 6 glucosidase and sucrose synthase responsible for alteration in cell wall structure and the degradation of starch into simple sugars and as result prolong storage life. These investigations are correlated with (Ladaniya and Sonkar, 1997) who reported that the Manually waxed Nagpur mandrine (Citrus reticulata) with 2000 ppm Carbendazim fungicide, packaged in ventilated corrugated fiber-board boxes lined with polyethylene, had maximum retention of natural freshness, firmness and shine in waxed treated fruit and decay was effectively controlled by fungicide during 21 days of storage at ambient temperature. The maintenance of the firmness and quality of fruit also depends on packaging material and MAP (Ladaniya and Sonkar, 1997; Rodov *et al.*, 1997; Rosa *et al.*, 2001), types or concentrations of coatings and ethylene absorbent used (Raje *et al.*, 1997; Baldwin *et al.*, 1999; Malik *et al.*, 2003). Chitarra *et al.* (2001) also observed that firmness of Tommy Atkins mango was significantly affected by storage duration, salt concentration and storage temperature. The texture of the mango was decreased from 125.21-69.68 N when packaged in ventilated carton and stored at 10±1°C and 80-90% RH.

Taste: It is obvious Table 2 that treatments and their interactions had highly significant effect on TAS score of mango during storage period. The TAS score was increased in coated fruit packaged in poly-carton was 3.81-5.20 with an average means of 4.48 in coated fruit packaged in polyethylene combinations as compared to control with minimum TAS score T1 (4.67) at ambient temperature during 25 days of storage at ambient temperature or at first day with very low on taste score (4.00). It is clear from Table 1 that statistically there was a significant effect of treatment on TAS score except T1 and T2 (4.67,4.60), or T5 and T6 (3.81, 3.94), an insignificant effect in between treatments, however these treatments were significantly different to one an others during 25 days of their storage. The maximum TAS score of late Chaunsa white mango were observed in T3 (5.20), followed by T4 (4.96), T2 (4.60), T6 (3.94) and T5 (3.81) however, having comparatively lower TAS score than control with minimum TAS score T1 (4.67) or at first day with very low on taste score (4.00) at ambient temperature during storage. The variation in the modified atmosphere due to different types of treatments might be caused of distinction in the improvement of TAS in treated fruit. The least TAS score in T2, T3, T4, T5 and T6 at 25th day showed that fruit were not fully ripened might be due to undesirable modified atmosphere, the biochemical or metabolic activities were slower that caused a delay in ripening process. Whereas, T1 having higher TAS score in Chaunsa mango might be due to comparatively more suitable environment in which starch was easily converted into simple sugars that enhanced the taste of ripened fruit during storage. These results are correlated with Kittur *et al.* (2001) who observed that maximum texture and taste depends on type of coating at ambient temperature (27±2^{o}C and 65% RH) and fruits having polysaccharide based coating formulations improved the sensory characteristics of banana and mango by maintaining dark green color, with glassy shining and moist-like appearance 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. Raje *et al.* (1997) who reported that taste score of Alphanso mangoes in India was affected by storage period and types of ethylene inhibitor used when stored at 32-36^{o}C and 70-75% RH. The lower sensory score (66.70) at first day of storage was increased to its maximum score (79.5) after 8 days in control samples and then spoiled as compared to the treated with ethylene adsorbent reached to the maximum taste score at later stage on 16th day of their storage. The ethysord treated fruit gave the highest score of 68.7, followed by oxidizer (68.2) and $KMnO_4$ treated (66.2) fruit after 16 days of storage. Thus retention of two dominant components of taste like sweetness due to sugar and sourness from organic acids in many fruits (Kays, 1991) depends on many factors like storage temperature (Opara *et al.*, 2000), types of packaging or MAP (Clarke *et al.*, 1997; Rodov *et al.*, 1997), hot water treatments for specific time (Nair *et al.*, 2001) and type of coating and its concentrations (Ladaniya and Sonkar, 1997; Malik *et al.*, 2003).

Flavor: The Table 2 indicates that treatments and their interactions had highly significant effect on flavor score of mango during storage. The flavor score in coated fruit packaged in poly-carton was 4.04-4.69 with an average means of 4.38 in coated fruit packaged in carton combinations as compared to control with maximum flavor score T1 (4.81) during 25 days of storage at ambient temperature or at first day with very low flavor score (3.00). These findings are generally correspond with Hayat *et al.* (2005) who reported that the organoleptic evaluation of Banky apple showed a decreasing trend in taste/flavor score from 9.00-4.48 with the passage of storage period and there was a significant superiority of treated fruit in the preservation of taste/flavor over control during storage at ambient temperature.

It is obvious from Table 2 that statistically there was a significant effect of all treatments on flavor score except T3 (4.59) and T4 (4.69) having an insignificant difference; however these treatments were significantly different to others during 25 days of their storage. The maximum flavor score of late Chaunsa white mango were observed in T4 (4.69), followed by T3 (4.59), T2 (4.50), T5 (4.19) and T6 (4.04) having comparatively lower flavor score as compared to control with maximum flavor score T1 (4.81) or at first day with very low flavor score (3.00) at ambient temperature during storage. The polyethylene with combination of coating, antiripening agent with or without disinfectant, are very effective to control on flavor score and delay ripening process. This difference in flavor retention might be due to different nature of treatment and variations in modified atmospheric conditions created by individual treatment. Similar findings by Ladaniya and Sonkar (1997) who reported that the combination of wax coating with 2000 ppm Carbendazim fungicide, packaged in ventilated Corrugated Fiber-Board Boxes (CFB) lined with polyethylene had maximum retention of natural freshness, firmness, total soluble solids and acid ratio, flavor and shine in treated fruit during 21 days of storage at ambient temperature. It was observed earlier that coatings improve the flavor of fruit that depends upon the type of coating and permeability of O_2. The polysaccharide based coatings had low permeability and anaerobic respiration caused an increased of ethanol and acetaldehyde content of fruit as a result reduction of flavor (Baldwin *et al.*, 1999), however, the higher CO_2, acteldehyde and ethanol levels may have contributed to a greater delay in ripening for NS fruit since these compounds are reported to have an effect on this process via retardation of ethylene synthesis. The retention of flavor also depend on concentrations of coating (Malik *et al.*, 2003) or MAP (Ladaniya and Sonkar, 1997; Rodov *et al.*, 1997) used etc.

Table 1: Effect of coating having fungicide, ethylene absorbent and antiripening agent packaged in cardboard carton on the physico-chemical composition of chaunsa white variety during storage

	Treatments						
	T1	T2	T3	T4	T5	T6	Overall effect of Carton-coat
Reducing sugar (%)	9.67ef	10.14d	11.58a	10.32cd	10.44bc	10.59b	10.73
Total invert sugar (%)	28.51b	29.58a	25.14d	26.70c	20.05n	24.58g	24.12
Sucrose	19.83a	18.34b	12.94h	16.60c	9.19n	15.99d	13.68
Total sugar (%)	29.38a	28.53b	24.34d	26.6c	19.57m	26.59c	24.75
Sugar acid ratio	103.6a	86.27b	45.55de	61.12c	22.63g	55.09cd	46.10

Mean values with different letters in same row are significantly different to each other at ($p<0.05$).

T1 = Control T2 = Carton T3 = Coat + NaOCl + Carton

T4 = Coat + $KMnO_4$ + Carton T5 = Coat+2,4,5-T + Carton T6 = Coat+2,4,5-T having oil + H_3BO_3-$CaCl_2$ + Carton

Table 2: Effect of coating having fungicide, ethylene absorbent and antiripening agent packaged in cardboard carton on the physico-chemical composition of chaunsa white variety during storage

	Treatments						
	T1	T2	T3	T4	T5	T6	Overall effect of Carton-coat
Skin colour	5.82a	4.80cd	5.01b	4.73de	4.31f	4.09g	4.53
Flesh colour	4.56c	4.70b	5.02a	4.79b	4.01e	4.05e	4.47
Texture	4.98ef	4.48g	4.90f	4.97ef	4.99ef	5.27c	5.03
Taste	4.67c	4.60c	5.20a	4.96b	3.81ef	3.94e	4.48
Flavour	4.81a	4.50cd	4.59bc	4.69ab	4.19e	4.04f	4.38

Mean values with different letters in same row are significantly different to each other at ($p<0.05$).

T1 = Control T2 = Carton T3 = Coat + NaOCl + Carton

T4 = Coat + $KMnO_4$ + Carton T5 = Coat+2,4,5-T + Carton T6 = Coat+2,4,5-T having oil + H_3BO_3-$CaCl_2$ + Carton

Conclusion: After a through study it is concluded that potential techniques of interactive packaging in cardboard carton had a significant effect on overall quality characteristics such as sugars, colour, texture, taste and flavour of chaunsa white variety of mango at ambient temperature during storage. The fruit under gone into different interactive potential techniques such Control (T1), Carton (T2), Wax-CMC having NaOCl coated fruit packed in Carton (T3), Wax-CMC Coated fruit with $KMnO_4$ package in Carton (T4), Wax-CMC Coating having 2,4,5-T in Carton (T5), H_3BO_3 and 2,4,5-T having oil treated fruit packed in Carton (T6) showed significant difference in quality characteristics among the treatments during storage. Moreover, treated fruit with a group of potential innovative techniques in cardboard carton were superior in quality than packaged in carton without treatments and due to slow process of ripening during storage treated fruit effectively maintained higher percent of sugars (RS, TIS, SUC and TS content) and higher retention of organoleptic characteristics up to the end of the storage. The present studies show that IPCC system having with other protective chemicals had a vital role in delaying the ripening process of mango fruit and extended storage life up to 25 days with minimum quality loss as compared to Control sample due to its unattractive skin, brown pulp color and poor taste was unacceptable after 12 days of their storage and had greater compositional changes with maximum quality loss during storage. Improving the present IPCC system by including polyethylene wrapping may increase further shelf life and therefore, further research studies are necessary for the development this system in near future.

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