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Effect of Pre-Treatments and Polyethylene Packaging on Overall Chemical Constituents Such as Sugars and Organoleptic Parameters like Colour, Texture, Taste and Flavour of Chaunsa White Variety of Mango During Storage

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Abstract: Polyethylene packaging and Pre-treatments had significant effect ($p<0.05$) on overall chemical constituents such as reducing and non-reducing sugars (RS, TIS, SUC) Total Sugars (TS), Sugar Acid Ratio (SAR) and other organoleptic parameters like; Skin Color (SKC), Flesh Color (FLC), Texture (TEX), Taste (TAS) and Flavour (FLA) of Chaunsa white variety of mango fruit at ambient temperature (28-33°C and 56.7-69.7% relative humidity) during storage. It was investigated that fruit treated with coating emulsions having fungicide, ethylene absorbent and antiripening agent, packed in polyethylene had lower RS ranged from (8.35-10.70%), TIS (17.78-24.66), SUC (9.07-13.75), TS (17.31-23.93), SAR value (25.31-39.79), lower SKC (.3.83-4.88), FLC (3.84-4.50), TEX (5.05-5.68), TAS (3.21-4.28) and FLA (3.74-4.76) with an average mean of 9.07%, 20.95%, 10.80%, 20.06%, 26.31, 3.93, 4.08, 5.20, 3.70 and 4.09 respectively at ambient temperature during 30 days of storage. The coated fruit packed in polyethylene had longer shelf life, minimum quality loss and slower increase in RS, TIS, SUC, TS contents, SAR, or lower score of SKC, FLC, TAS, higher TEX and slower increase of FLA respectively of fruit during storage. Whereas, the control sample had greater compositional changes with maximum quality loss, higher RS (9.67%), TIS (28.51%), SUC (19.83%), TS (29.38%), SAR (103.60), SKC (5.82), FLC (4.56), TAS (4.67), FLA (4.81) and lower TEX (4.98) and fruit was unacceptable after 12 days of their storage due to its unattractive skin, brown pulp color and poor taste.

Key words: Fruit, chaunsa mango, polyethylene packaging, pre-treatments, sugars, organoleptic characteristics, physico-chemical composition

INTRODUCTION

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). For prevention or delaying of these changes during storage both at national and international market great emphasis is given to consumer packaging for safety of the fresh produce, organoleptic characteristics, agro-economics and flexibility. The protection of fruit up to the final chain of consumer is totally depending on the selection of proper packaging materials, which is an essential prerequisite. Pre-packing or consumer packing is also convenient for retailers as well as customers and therefore adds value to the produce. Waxes are esters of higher fatty acids with monohydric alcohols and hydrocarbons and some free fatty acids that are generally used for coating fruits and vegetables to improve the appearance of produce or to delay deterioration. The ripening is induced or delayed by applying growth regulators like 2,4 5-Trichlorophenoxy acetic acid or 2,4 D-Dichlorophenoxy acetic acid or Malic Hydroxide (MH) and Naphthalene Acetic AcidS (NAA) and ethylene absorbent like $KMnO_4$ along with packaging in polyethylene or wooden or carton is an innovative approach of food preservation (John, 2008). In a recent study, it was reported that mango fruit stored in wax-lined cartons sealed with chitosan films have 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 perforated plastic boxes (Srinivasa, *et al.*, 2004). Fresh fruits and vegetables contain 80-90% moisture by weight. As the moisture evaporates there is shriveling, weight loss and discoloration. Wax is meant to retard this problem. Wax coating reduces moisture loss by 30-40% during storage and 1.5-3% wax emulsion in water increased storage life of mangoes by 50% whereas increasing wax concentration to 50% can lead to development of off flavour. Coating reduces water loss, lessens softening, reduces losses of ascorbic acid, inhibits malic enzyme activity and increases polygalactrouronase activity (Panhar and Panhar, 2008). In India banana and mango treated with polysaccharide based coating formulations of starch, Carboxymethyl cellulose, or chitosan, blended with a suitable lipid and wetting agent had retarded color development, lower acidity, increased firmness values and reduced in weight loss and CO_2 evolution. It was also noted that Chitosan based coatings were much superior in prolonging the shelf life and quality of mango (Kittur *et al.*, 2001). It was investigated that the life of Baneshan mango was extended from 6-9 days by low temperature (5-13°C) as compared to its normal life of 4 days at ambient temperature. The life was further extended to 8, 12 and 23 days at room temperature, cool chamber and cold storage respectively when treated with bavistin fungicide, paraffin wax and wrapping with HM-film that provide modified atmosphere coupled with low temperature (Narayana *et al.*, 1996). 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. Post harvest application of $CaCl_2$ indicated slight 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). 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 effect of these techniques on the sugars and organoleptic characteristics of chaunsa white variety of mango at ambient temperature during storage. Therefore, the aim of the present study was to evaluate the effect of pre-treatments and polyethylene packaging on overall chemical constituents such as reducing- non reducing sugars, total sugars, sugar acid ratio and other organoleptic parameters like color, texture, taste and flavour of chaunsa white, an important commercial variety of mango at ambient temperature during storage.

MATERIALS AND METHODS

Collection of sample: For present research studies, Chaunsa white, very important commercial variety of mango, was selected and for this purpose unripe, matured, hard green and uniform size of freshly arrived fruit were purchased from wholesale fruit market in Islamabad.

Hot water treatment: Chaunsa white variety of mango fruit were immediately transferred from wholesale market to post harvest laboratory of Department of Food Technology in University of Arid Agriculture Rawalpindi. After careful sorting, fruit 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.

Preparation of coating materials: Potassium per magnate saturated solution, potassium per magnate super saturated solution. ($KMnO_4$), calcium chloride 1%, boric acid 1% solution, sodium hypochlorite (NaOCl) 800 ppm, 0.85% saline water, CMC 4% solution, trichlorophenoxy acetic acid 1% solution, coating emulsion of Bee wax, oil, saline water, lecithin as emulsifier, CMC as stabilizer and sodium hypochlorite as fungicide were prepared.

Grading, coating, packaging and storage: Chaunsa white late commercial variety of mango 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 (T_1), Polyethylene (T_2), Wax-CMC having Sodium Hypochlorite coated fruit packed in polyethylene (T_3), Wax-CMC Coated fruit with $KMnO_4$ package in Polyethylene (T_4), Wax-CMC Coating having 2,4,5-T in Polyethylene (T_5), H_3BO_3 and 2,4,5-T having oil treated fruit packed in Polyethylene (T_6). These treated fruit 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 after three days interval 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 flavour 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

Reducing sugar: Table 1 shows 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 polyethylene was increased from 8.35-10.70% with an average mean of 9.07% during 25th day 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

Table 1: Effect of pre-treatments and polyethylene packaging on overall chemical constituents such as sugars and organoleptic parameters like color, texture, taste and flavour of Chaunsa white variety of mango during storage

	Treatments						
Parameters	Control T_1	Polyethylene T_2	Coat+ NaOCl +Poly T_3	Coat+ $KmnO_4$ +Poly T_4	Coat+ 2,4,5-T +Poly T_5	Coat+2,4,5-T having oil+ H_3BO_3 - $CaCl_2$ +Poly T_6	Overall effect of poly -coat
RS	9.67ef	10.70d	9.83e	9.73e	8.39i	8.35i	9.07
TIS	28.51b	24.66f	22.19j	24.27h	19.55o	17.78p	20.95
SUC	19.83a	13.75e	11.81jk	11.73k	10.61m	9.07o	10.80
TS	29.38a	23.93f	21.55i	22.31g	19.06n	17.31o	20.06
SAR	103.6a	39.79ef	26.86fg	27.22fg	25.84fg	25.31g	26.31
SKC	5.82a	4.88c	3.83h	4.11g	3.88h	3.89h	3.93
FLC	4.56c	4.50c	3.84f	4.26d	4.10e	4.12e	4.08
TEX	4.98ef	5.68a	5.05e	5.10de	5.43b	5.21cd	5.20
TAS	4.67c	4.28d	3.90e	3.75f	3.92e	3.21h	3.70
FLA	4.81a	4.76a	4.34de	3.91fg	4.40d	3.74h	4.09

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 T_3 and T_4 (9.83, 9.73) and T_5 and T_6 (8.39 8.35) an insignificant difference in between treatments was noted, however these groups of treatments were significantly different from other treatments. The maximum percent reducing sugar was observed in T_2 (10.70%), followed by T_3 (9.83%), T_4 (9.73 %) as compared to control T_1 (9.67 %), moreover, T_5 (8.39%) and T_6 (8.35%), respectively had lower percent reducing sugar than control 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 (T_2), or the combination as poly-coat might be due to controlled or modified atmosphere showed better development of RS at later stage on 18th day as compared to control. It was also observed that addition of Wax-CMC coating having ethylene absorbent or antiripening agent in T_3 or T_4 showed greater retention than T_5 or T_6 in polyethylene had comparatively lower RS contents as compared to packing in polyethylene or control. Furthermore, these treatments also reached to maximum RS at later stage on 18th day might be due to the difference in combination of coating with packing produced better environment that reduced metabolic process and 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)S who also reported that mango and banana treated with polysaccharide-based coatings had lower reducing sugar contents than control at ambient temperature (27±2^{o}C and 65 % RH, suggesting that the former synthesized reducing sugar at lower rate than control during storage. The results of the present studies show that coating having fungicide, ethylene absorbent, antiripening agent and antiripening agent with oil and disinfectant had role in retaining higher percent reducing sugar at later stage at ambient temperature might be very effective to control RS 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 all treated fruit was ranged 17.78-24.66% with an average means of 20.95% in coated fruit packaged in polyethylene as compared to control having maximum total invert sugar percent (28.51%) after 25th day 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 increase 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 T_2 (24.66%), followed by T_4 (24.27%), T_3 (22.19%) T_5 (19.55%) and T_6 (17.78%) as compared to control having maximum total invert sugar percent (28.51%) after 25th day 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 as compared to polyethylene, the efficiency of polyethylene packaging was improved further, by coating the fruit with Wax-CMC having fungicide, ethylene absorbent or antiripening agent in T_3, T_4, T_5 and T_6 and these combinations of poly-coat packaging had reduced the ripening process might be due to reduction in metabolic activities by modified atmosphere produced by treatments during storage.

Sucrose: 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 and the percent sucrose sugar in all the treatments was 9.07-13.75% with an average means of 10.80% after 25^{th} day of storage at ambient temperature as compared to control with maximum percent sucrose content T_1 (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 was observed in T_2 (13.75%), followed by T_3 (11.81%), T_4 (11.73%) T_5 (10.61%) and T_6 (9.07%), however, these treatments maintained sucrose of mango at lower level as compared to control with maximum percent sucrose content T_1 (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 T_3, T_4 T_5 and T_6 respectively with minimum sucrose content might be due to reduction in metabolic activities by a modified atmosphere produced by combination 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: 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 were 17.31-23.93% with an average means of 20.06% in treated fruit packaged in polyethylene as compared to control with maximum total sugar percent T_1 (29.38%) after 25^{th} day 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 was found during 18 days of their storage. The maximum total sugar percent of late Chaunsa white mango was observed in T_2 (23.93%), followed by T_4 (22.31%), T_3 (21.55%), T_5 (19.06%) and T_6 (17.31%) however, these treatments having comparatively lower percent sucrose content as compared to control with maximum total sugar percent T_1 (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 12^{th} day and then spoiled, whereas, low-density polyethylene (100 gauge LDPE) top covered carton boxes fruit gave the maximum values on 16^{th} day at ambient temperature 27±1°C at 65% RH respectively. The results of the present studies shows that both of the packaging and coating had maintained the total sugar percent at lower level by delaying the ripening process of chaunsa white mango during storage.

Sugar acid ratio: Table 1 presents that treatments and their interactions had highly significant effect on sugar acid ratio of mango during storage and the sugar acid ratio was 25.31-39.79 with an average means of 26.31 in poly-coating combinations as compared to control with maximum sugar acid ratio T_1 (103.6 %) after 25^{th} day 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 during 18 days of their storage. The maximum sugar acid ratio of late Chaunsa white mango was observed in T_2 (39.79%), followed by T_4 (27.22%), T_3 (26.86%), T_5 (25.84%) and T_6 (25.31%) however, these treatments having comparatively lower sugar acid ratio as compared to control with maximum sugar acid ratio T_1 (103.6%) or at first day with very low sugar acid ratio (8.21%) at ambient temperature during storage. Manzano *et al.* (1997a,b) observed similar decreasing trend in Hadden mango treated with wax 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 untreated fruit. These results 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 wax treated fruit. The results of the present studies shows that Chaunsa white packaged in Polyethylene had lower sugar acid ratio, however that ratio was further reduced when coated fruit was packed in same packing and become very effective in delay ripening with minimum sugar acid ratio during storage.

Skin color: Table 1 illustrates that treatments and their interactions had highly significant effect on skin color score of mango during storage. The skin color score was 3.88 to 4.88 with an average means of 3.93 in poly-coating combinations as compared to controlled with maximum skin color score T_1 (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 1 that statistically there was a significant effect of treatment on SKC score except T_3, T_5 and T_6 (3.83, 3.88 and 3.89) 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 T_2 (4.88), followed by T_4 (4.11), T_6 (3.89), T_5 (3.88) and T_3 (3.83) as compared to controlled with maximum skin color score T_1 (5.82) during 18 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 and Manzano *et al.*, 1997a,b). 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.*, 1997a,b; Kittur *et al.*, 2001), hot water treatment before storage (Opara *et al.*, 2000; Mortuza and Reza, 2001), coating concentrations and temperature during storage (Carrillo *et al.*, 2000; Malik *et al.*, 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 had a role in retaining color than control and coating, coating having fungicide or ethylene absorbent or with antiripening and coating with antiripening agent with oil and disinfectant packed in polyethylene had slower increase in color score might be due to slow ripening process and therefore, may be very effective to control ripening process with minimum skin color score during storage.

Flesh color: Table 1 indicates that treatments and their interactions had highly significant effect on flesh color score of mango during storage. The skin color score was 3.84-4.5 with an average means of 4.08 in poly-coating combinations as compared to control T_1 (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). 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 1 that statistically there was a significant effect of all the treatments on flesh color score except T_1 or T_2 (4.56, 4.50) or T_5or T_6(4.10, 4.12) having an insignificant difference observed during 18 days of their storage. The maximum flesh color score of late Chaunsa white mango was observed in T_2 (4.50), followed by T_4 (4.26), T_6 (4.12), T_5 (4.4.10) and T_3 (3.84) and having comparatively lower flesh color score than controlled T_1 (4.56 or at first day with minimum flesh color score (2.5) at ambient temperature during storage. Carrillo *et al.* (2000) also stated that Haden mangoes coated with different concentrations of Semperfresh had higher retention of green color as compared to noncoated fruit at 13°C during 32 days of storage. Manzano *et al.* (1997a,b) evaluated the effect of coatings on color development in Hadden mango and reported that mango treated with wax 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 T_2, T_5 and T_6 had no significant difference in FLC with control (T_1) 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 maintain flesh color as compared to T_2, T_3, T_4 and T_6 maintained higher FLC up to end of storage might be due to inactivation of enzymes and modified atmosphere slower process of changes in chlorophyll. These results are inline 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 minutes than for 5 min of hot water treatment. 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 $KMnO_4$ 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 in 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. The results of the present studies show that Chaunsa white coated having fungicide and coating with Ethylene absorbent packed in polyethylene were more effective to control the flesh color by delaying the ripening process during storage.

Texture: Table 1 reveals that treatments and their interactions had highly significant effect on TEX score of mango during storage. The TEX score was 5.10-5.68 with an average means of 5.20 in coated fruit packaged in polyethylene combinations as compared to control with minimum TEX score T_1 (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, there is 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 shrivelling 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 T_4 and T_6 (5.10, 5.21), 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 T_2 (5.68), followed by T_5 (5.43), T_6 (5.21), T_4 (5.10) and T_3 (5.5.05) as compared to control with minimum TEX score T_1 (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 those treatments with Wax-CMC coating with $KMnO_4$ and 2, 4, 5-T in T_4 and T_5 respectively were more effective to retain higher texture of fruit at later stage on 25th day 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 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 a 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 wax 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. The results of the present studies shows that coated Chaunsa white packaged in polyethylene were very effective to control texture score and delay ripening process having maximum TEX retention as compared to controlled during storage at ambient temperature.

Taste: It is obvious from Table 1 that treatments and their interactions had highly significant effect on TAS score of mango during storage period. The TAS score was ranged from 3.21-4.28 with an average means of 3.70 in coated fruit packaged in polyethylene combinations at ambient temperature during 25 days of storage at ambient temperature. It is clear from Table 1 that statistically there was a significant effect of treatment on TAS score except T_3 and T_5 (3.90, 3.92 an insignificant effect in between treatments, however these treatments were significantly different to others during 18 days of their storage. The maximum TAS score of late Chaunsa white mango were observed in T_2 (4.28), followed by T_5 (3.92), T_3 (3.90), T_4 (3.75) and T_6 (3.21) however, these treatments having comparatively lower TAS score than control with higher TAS score T_1 (4.67) or at first day with 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 T_2 T_3 T_4 T_5 and T_6 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, T_1 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°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°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).

Flavour: Table 1 indicates that treatments and their interactions had highly significant effect on flavour score of mango during storage. The flavour score was 3.74-4.76 with an average means of 4.09 in coated fruit packaged in polyethylene combinations as compared to control with maximum flavour score T_1 (4.81) during 25 days of storage at ambient temperature or at first day with very low flavour 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/flavour 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/ flavour over control during storage at ambient temperature. It is obvious from Table 1 that statistically there was a significant effect of all treatments on flavour score except T_1 (4.81) and T_2 (4.76) T_4 having an insignificant difference; however these treatments were significantly different to others during 25 days of their storage. The maximum flavour score of late Chaunsa white mango were observed in T_2 (4.76), followed by T_5 (4.40), T_3 (4.34), T_4 (3.91) and T_6 (3.74) having comparatively lower flavour score as compared to control with maximum flavour score T_1 (4.81) or at first day with very low flavour 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 flavour score and delay ripening process. This difference in flavour 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, flavour and shine in treated fruit during 21 days of storage at ambient temperature. It was observed earlier that coatings improve the flavour 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 increase of ethanol and acetaldehyde content of fruit as a result reduction of flavour (Baldwin *et al*., 1999), however, the higher CO_2, acetaldehyde 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 flavour also depend on concentrations of coating (Malik *et al*., 2003) or MAP (Ladaniya and Sonkar, 1997; Rodov *et al*., 1997) used etc.

Conclusion: After a through study, it is concluded that fruit packed either in Polyethylene alone or fruit treated with coating emulsions having fungicide, ethylene absorbent and antiripening agent packed in polyethylene had played a very effective and vital role to control compositional changes by delaying the ripening process and with a minimum quality loss and longer storage life, as compared to the control sample had greater compositional changes with maximum quality loss and short storage life during storage at ambient temperature. Mean values with similar letters in same row are not significantly different; otherwise they are significantly different to each other at ($p<0.05$).

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