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Effect of Storage on Physico-Chemical Composition and Sensory Properties of Mango (*Mangifera indica* L.) Variety Dosehari

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Abstract: The effect of storage on physico-chemical changes such as weight loss (wt. loss), total soluble solids (TSS), titratable acidity (TA) and sensory evaluation such as skin color (SKC), flesh color (FLC), texture (TEX), taste (TAS) and flavor (FLA) of packaged Dosehari mango in cardboard carton of export quality, having one hole in each sidewall on four sides confronting each other, in order to maintain the modified atmosphere were recorded after an interval of 3 days at ambient temperature (32-35°C with 53.6-78.8% RH). 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. A significant effect of storage ($P<0.05$) on Dusheri variety of mango was observed and had an increasing trend of average percent wt. loss (0.00 to 36.1 %), TSS (10 to 25.27 %), and decreasing trend of percent TA (0.5% to 0.094 %) with an average mean of 15.67 %, 11.55 % and 0.28% respectively during 15 days of storage period. The SKC score was increased from 5.0 to 8.70, FLC (5.0 to 8.44), TEX (6.00 to 8.68), TAS (5.00 to 8.46) and FLA score was increased from 5.0 to 7.61 with an average means of 4.22, 4.01, 4.43, 4.32, and 3.84 respectively during 15 days of storage at ambient temperature. It was also observed that in general the SKC score had increased up to (6.91) at 6th day, FLC (5.73), TEX (6.83), TAS (6.07) and FLA (5.67) score had increased at 3rd day of storage and then gradual decreased to 1.25, 1.83, 1.35, 1.67 and 1.57 respectively at 15th days of storage, therefore, showing an increasing trend first and then significant decreased of SKC, FLC, TEX, TAS and FLA score respectively during storage. Whereas control showed higher percentage of wt. loss (19.88%), lower retention of TSS (9.43%) or TA (0.15%), and very low score of other quality parameters such as SKC (1.71), FLC (1.58), TEX (1.82), TAS (1.61) and FLA (1.47), respectively during 15 days of storage period.

Key words: Fruits, Dosehari mango, storage temperature, storage period

Introduction

Mango (*Mangifera indica* L Family *Anacardiaceae*) commonly called "King of fruits", is native to Southern Asia, especially Burma and Eastern India. Mango is considered as fruit of excellence and thus has prominent position among commercial fruits grown in Pakistan. It is famous for its excellent flavor, attractive fragrance and nutritional value. Mango plays an important role in balancing the diet of human being by providing about 64-86 calories energy. Mango as an emerging tropical export crop is produced in about 90 countries in the world with a production of over 25.1 million tones. Asia is the main producer with 76.9% of the total world production, followed by America with 13.38%, Africa with 9% and less than 1% each for Europe and Oceania. Pakistan stands at 5th position among main mango producing countries with production of 938000 tones with a share of 7.6% in the world market (Sauco, 2002).

Mango is the second major fruit crop in Pakistan. At present it is grown on an area of 93.5 thousand hectares. Pakistan is blessed with many important leading commercial varieties of mango such as Sindhri, Langra, Anwar Ratol, Summer Bisht, Fajri, Fazali, Zafran, Saroli, Dusheri, Gulab Khas, Swarnarica, Bagan Pali, Chuansa Black & White, and Neelum (Amin and Hanif, 2002). The climate of Sindh gets warmer about one month earlier than that of Punjab which has given the privilege to the province to grow early varieties of mango. Subsequently, a new trend of growing late varieties in Punjab has received a wide popularity, which has extended the market period, adding in the exportable surplus and production in excess of local demand.

Mango being a climacteric fruit possesses a very short shelf life and reach to respiration peak of ripening process on 3rd or 4th day after harvesting at ambient temperature (Narayana *et al.*, 1996). The shelf life of mango varies among its varieties depending on storage conditions. It ranges from 4 to 8 days at room temperature and 2-3 weeks in cold storage at 13°C (Carrillo *et al.*, 2000). A difference among varieties exhibited 4 days of shelf life for Baneshan, Tomy Atkins

and Kit (Narayana *et al.*, 1996, Rodov *et al.,* 1997) as compared to 8-9 days of Alphanso (Raje *et al.,* 1997; Srinivasa *et al.,* 2002). Usually after harvest the ripening process in mature green mango takes within 9-/12 days (Herianus *et al.,* 2003) or 12-14 days (Manzano *et al.*, 1997) with good flavor, texture and color characteristic at ambient conditions at 25°C. The ripening process of mango fruit involves a series of biochemical reactions or metabolic activities that cause chemical changes, increased respiration, ethylene production, change in structural polysaccharides causing softening, degradation of chlorophyll develops pigments by carotenoids biosynthesis, changes in carbohydrates or starch conversion into sugars, organic acids, lipids, phenolics and volatile compounds, thus leading to ripening of fruit with softening of texture to acceptable quality (Herianus *et al.,* 2003).

Due to mishandling, inadequate storage or lack of post-harvest technical knowledge producers and traders have to face about 20-30% losses (Tahir *et. al.*, 2002) and loss of this perishable commodity is estimated up to 320.7 thousand tons annually with a value of Rs. 3.0 billion in the country (Haq, 2002). Spoilage of mango due to stem end and Anthracnose, limits its storage potential and the shelf life is decided on the bases of spoilage (10%) during storage (Narayana *et al.*, 1996).

In Israel MAP technique of polyethylene perforated and nonperforated sealed packaged coupled with low temperature at 14°C for 3 weeks and then at 20°C for 4 days when applied to Tommy Atkins during storage showed no decay until opening in nonperforated pack, and then rotted rapidly. Data obtained on shelf life, weight loss, spoilage and retention of Vitamin C indicated that cool chamber was an ideal storage technique (Pal, 1998).

The loss of water from fruit is due to skin evaporation (transpiration) and to some extent respiration. If the fruit looses weight, shriveling will occur and the appearances will deteriorate thus reducing its market value. Polyethylene wrapping reduces the rate of respiration by creating a modified atmosphere (MAP) around the fruits and thereby retard the senescence and ripening. The decay incidence in perforated packages did not exceed 10-12% as compared to 20% decay in control. It is observed that combination of MAP with effective decay controlling measures can extend the post harvest life of mango fruit (Rodov *et al.*, 1997). The aim of this study was to investigate the keeping quality of packaged Dosehari mango in cardboard carton of export quality having one hole in each sidewall on four sides confronting each other, in order to maintain the modified atmosphere during storage at room temperature.

Materials and Methods

Collection of Sample: For present research studies Dosehari one of very important commercial varieties of mango was selected and for this purpose unripened, matured, hard green and uniform size of fresh fruit was purchased from wholesale fruit market in Islamabad.

Hot water treatment: Dosehari mango was immediately transferred from wholesale market to post harvest laboratory of department of Food Technology in University of Arid Agriculture Rawalpindi and after careful sorting, mango fruit was subjected to hot water treatment in cotton bags at 53°C for three minutes and immediately cooled by dipping in cold water at 20 °C and air dried.

Grading and packaging: All of the treated fruit was graded according to their size and were packed in cardboard boxes of export quality having 3 numbers in each box having one hole in each sidewall on four sides confronting each other in order to maintain the modified atmosphere. Where as the control sample was kept as such for comparison to other treated fruit at same ambient conditions during storage.

Storage: All of the treated fruit was stored at ambient temperature i.e., 32-35°C with 53.6-78.8%, relative humidity for a storage period of 15 days. The effect of storage on shelf life and Physico-chemical changes such as weight loss, total soluble solids (TSS), titratable acidity (TA), and sensory evaluation such as skin color (SKC), flesh color (FLC), texture (TEX), taste (TAS) and flavor (FLA) was observed after an interval of 3 days for 15 days of storage period at ambient temperature.

Weight loss: Weight of the fresh harvested fruit was determined at the farm by electronic digital balance by adjusting the balance through g scale button. Every sample for weight loss determination was allotted a specific number in order to avoid any in convenience or disorder during storage. The weight loss of packaged mango in cardboard carton was observed after an interval of 3 days for a period of 15 days. Preliminary quality parameter such as weight loss was calculated by standard procedure as mentioned in AOAC (1994).

% Weight loss = wt. of first interval – wt. of 2nd interal x 100 / wt. of first interval

Total soluble solids: The total soluble solids were determined by Refractometer. Homogenous sample was prepared by blending the peeled mango flesh in blender. The sample was thoroughly mixed and a few drops were taken on prism of refractometer and direct reading was taken by reading the scale in meter as described in AOAC (1994).

Acidity determination : The acidity of the sample was determined by taking 10 ml sample into 100 ml volumetric flask and volume was made up with distilled

water. Then 10 ml of sample was taken into conical flask was titrated against alkali such as 0.1 N NaOH solution according to AOAC (1994). The percentage of acidity was calculated as: -

Acid % = 1/10 x Eq. Wt of acid x Titer x 100/ Weight of the sample

Sensory evaluation: The sensory evaluation of fruit was 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 (1987).

Statistical analysis: 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) to compare the mean values obtained according to the method described by Steel and Torrie (1980).

Results and Discussion

Weight loss: The reduction in weight is attributed to the physiological loss in weight (PLW) due to respiration, transpiration of water through peel tissue and other biological changes taking place in the fruit. Highly significant effect of storage on percent weight loss of mango fruit was observed during storage. The loss of weight significantly increased following an ascending order of ranking through out the storage period and significantly highest loss in weight of mango fruit was observed at last day of storage. Table 1 shows that in general Dosehari variety of mango had an increasing trend of average percent weight loss from 0.00 to 36.1% with an average mean of 15.67% with the passage of storage time. 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. However, weight loss was lower in coated fruit (4.0 to 6.5%) as compared to control having higher percent weight loss (0.00 to 9.0%). These results are further in line with Doreyappa-Gowda and Huddar (2001) who observed that mature green Alphanso and other 7 varieties of mango fruit were influenced by size of fruit, storage temperature, variety and the reduction in length and thickness of fruit during ripening process were attributed to shrivelling of fruits due to higher percent loss of water (12.8%) from fruits when stored at high temperature (18-34°C). Perez *et al.* (2004) also observed that weight loss in Avocado fruit was linear at both the storage temperatures. It was 4.3% at 20°C for 8 days and 3.0% at 10°C for 22 days also affected the storage life and had higher storage life of upto (32 or 22 days) in those fruit stored at low temperature (7 and 10°C) as compared to high temperature storage (20° C or 25°C) with 8 or 6 days of storage life.

Total soluble solids: It was observed that total soluble solids contents were increased from 10 to 16.23 % up to 6th day of their storage and thereafter, a gradual decrease up to (6.13 %) was observed after 15th days of storage period (Table 1). The increase in TSS might be due to the alteration in cell wall structure and breakdown of complex carbohydrates into simple sugars during storage. This increase and decrease in TSS are directly correlated with hydrolytic changes in starch and conversion of starch to sugar being an important index of ripening process in mango and other climacteric fruit and further hydrolysis decreased the TSS during storage (Kays, 1991; Kittur *et al.*, 2001). Similar pattern of TSS was observed in green mature Alphanso and other 7 hybrids or varieties of mango fruit that under gone a series of physico-chemical changes and the major changes were increased in TSS content from 8.55 to 19.0° Brix during ripening stored at 18-34°C (Doreyappa-Gowda and Huddar, 2001). The slight variation might be due to the storage conditions and variation of varieties. Similar views were expressed by Manzano *et al.* (1997) who observed that temperature of storage also affect TSS contents and TSS contents were low (14.15%) at high temperature (25°C) as compared to higher TSS contents (16.6%) at low temperature (12°C) during 20 days of storage.

Titratable acidity: The change in titratable acidity of the mango (Dosehari var.) recorded during storage at ambient temperature of 32-35°C is presented in Table 1. The results revealed that percent titratable acidity of treated Dosehari mango ranged from 0.5% to 0.094% with an average means of 0.28% during storage. It was observed that percent titratable acidity had decreasing trend during 15 days of storage period that might be due to the degradation of citric acid which could be attributed to increased activity of citric acid glyoxylase during ripening or reduction in acidity may be due to their conversion into sugars and their further utilization in metabolic process in the fruit. These results coincided with those Doreyappa-Gowda and Huddar (2001) who reported the similar pattern in different varieties of mango fruit stored at 18-34°C under gone a series of physico-chemical changes during ripening and the major changes were considerably increased in pH from 2.85 to 4.38 and decreased in acidity from 2.71 to 0.04% during ripening. These results further correspond with Srinivasa *et al.* (2002) who found that titratable acidity values of Alphonso mango either packed in carton or control sample also showed a decreasing trend from 2.17% to 0.08% on 12th day when stored at ambient temperature 27±1°C and 65% RH. Similar changes were noted by Kudachikar *et al.* (2001) in Neelum mango which had optimum stage of maturity 110 days after the fruit set and pH value decreased (3.0) and acidity increased (1.9%) upto 90 days after the fruit

Table 1: Overall effect of storage period on the composition of Dosehari Mango at room temperature

Storage	wt. loss	TSS	TA	SKC	FLC	TEX	TAS	FLA
0	0	10	0.5	5	5	6	5	5
3	4.165	14.34	0.3794	6.295	5.731	6.833	6.069	5.667
6	9.635	16.23	0.305	6.907	5.362	6.188	5.603	5.232
9	17.12	13.9	0.2606	3.866	3.684	3.749	4.751	3.354
12	27.03	8.707	0.16	2.019	2.443	2.392	2.823	2.251
15	36.1	6.136	0.09444	1.254	1.834	1.353	1.672	1.57
Mean	15.67	11.55	0.28	4.22	4.01	4.43	4.32	3.84

set. Later, pH slightly increased (3.1) and acidity slightly decreased (1.5%) at 110 days after fruit set.

Skin color: It is famous that consumer eats with his eyes and the major quality characteristic that create attraction towards the fruit is its color, which is one of the important quality parameters. During study color of mango was evaluated by a trained panel of judges using nine point hedonic scales after an interval of 3 days at ambient temperature (32-35°C with 53.6-78.8% RH. The results revealed that the skin color score was increased up to 6.91 at 6th day of storage and then gradually decreased to 1.25 at 15th days of storage, (Table 1), therefore, showing an increasing trend first and then significant decreased of skin color score during storage. 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). Thes results coincide with those of Doreyappa-Gowda and Huddar (2001) who reported that the concentration of carotenoids were increased due to a series of physico-chemical changes in green mature Alphaso and other varieties of mango stored at 18-34°C during ripening and 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.

The main factors that retain mango quality in MAP are increased CO_2 levels and decreased O_2 levels which reduce respiration rates. These findings are further supported by Yahia and Hernandez (1993) who observed that fruit stored in open atmosphere (in air) lost their green color while those stored in control atmosphere remained green, and when transfered to air for normal ripening turned yellow but they were still more green than fruit stored continuously in air. This mean that fruit stored at low oxygen concentration atmosphere showed decrease in respiration rate, ethylene production, flesh firmness or color losses and the fruit ripening is indicated by changes in respiration rate, flesh firmness and skin color. 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), MAP (Rodov *et al.*, 1997; Srinivasa *et al.*, 2002) and temperature during storage (Carrillo *et al.*, 2000; Malik *et al.*, 2003).

Flesh color: Table 1 shows that in general, the flesh color score was increased during 15 days of storage at ambient temperature. It was observed that the flesh color score had increased up to 5.73 at 3rd day of storage and then gradual decreased to 1.83 at 15th days of storage, therefore, showing an increasing trend first and then significant decrease of skin color score during storage. The increase in color score during storage might be due to series of physico-chemical changes like the breakdown of chlorophyll and increase in carotenoid pigments of the pulp caused by enzymatic oxidation and photo degradation. These findings generally coincide with Doreyappa-Gowda and Huddar (2001) who reported that the green peel color of mature Alphanso and other varieties of mango was turned from light green or green or dark green to light yellow or yellow or orange yellow due to the breakdown of chlorophyll due to a series of physico-chemical changes during ripening, 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 fruit stored at 18-34°C undergone a series of changes and one of the major changes were increased in carotenoids from 498 to 8071 ug/100 g. The main factors that retain mango quality in MAP are increased CO_2 levels and decreased O_2 levels which reduce respiration rates. These findings are further supported by Yahia and Hernandez (1993) who observed that fruit stored in open atmosphere (in air) lost their green color while those stored in control atmosphere remained green, and when transferred to air for normal ripening turned yellow but they were still more green than fruit stored continuously in air. This mean that fruit stored at low oxygen concentration atmosphere decreased respiration rate, ethylene production, flesh firm or color losses and the fruit ripening is indicated by changes in respiration rate, flesh firmness and skin color. The delay in ripening and

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Texture: Texture is one of the important quality parameters in sensory evaluation, which play an important role at time of selection of fruit by consumer. 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). The studies on this quality parameter were carried out in prevaling conditions. Table 1 shows that in general, the texture score was increased from 6.00 to 6.83 with an average means of 4.43 during storage at ambient temperature. The texture score showed an increasing trend first up to 6.83 at 3rd day of storage and with passage of storage time a significant decreased in texture score to 1.35 at 15th days of storage was observed. The reduction in texture score during storage, 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 (Weichmann, 1987) formed in the tissues during ripening. The declining concentration of calcium might reduce calcium pectin interactions, allowing free release into flesh leading to reduce firmness as the fruit ripen and further breakdown caused shrivelling or over-ripening of mango fruit. The faster reduction in texture score in control sample might also be due to accelerated ripening process in free atmospheric conditions of storage temperature etc. These findings are correlated with Opara *et al.* (2000) in Vietnam, who reported that firmness of Buoi mango was highly dependent on storage temperature and increase in temperature (27^{o}C) accelerated ripening, reduced firmness from 63.4 to 26 N with the passage of storage time and fruit quality became unacceptable between 10-15 days as compared to cold storage of fruit at 7^{o}C or 12^{o}C maintained fruit firmness (63.7 to 37.6 N) during 25 days of storage and extends the storage life to over 3 weeks. Similar observations were reported by Doreyappa-Gowda and Huddar (2001) in green mature Alphaso and other 7 varieties of mango that firmness was decreased from (28.96-17.46 lbs/sq.inch) at 18-34^{o}C due to a series of physico- chemical changes.

Taste: 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). Table 1 shows that in general, the taste score was increased from 5.00 to 6.07 at 3rd day of storage and then gradually decreased to 1.67 at 15th days of storage, therefore, showing an increasing trend first and then significant decreased of the taste score during storage, might be due to the fluctuations in acids, pH, and sugar/acid ratio. It is evident that sugar and acids as a primary taste compounds, enhance human perception of specific flavor notes in mango, including aromatics, however, pH, TA, and TSS/TA were related well to sourness, astringency, and biting (Malundo *et al.*, 2001)

Flavour: Flavor is the blend of taste and smell perceptions noted when food is in the mouth. The overall flavor 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. It was observed from the results that the flavor score had increased up to 5.66 at 3rd day of storage and then gradual decreased to 1.57 at 15th days of storage (Table 1), therefore, showing an increasing trend first and then significant decreased of flavor score during storage.

Therefore, the biochemical changes were slower and conversion of complex organic compound into esters, aldehydes, acids, alcohols, ketones and ethers that contribute significantly to the aroma/ flavor (McWilliam, 1989) were developed at later stage than $CaCl_2$ treated fruit. Whereas in control, the maximum decline in flavor scores (1.31) was observed at 6th day of their storage and then spoiled, might be due to the fast changes in these volatile compounds in free atmosphere. These results are corresponding with Hayat *et al.* (2005) and Raje *et al.* (1997) who reported that the organoleptic evaluation such as taste/flavor of Banky apple or Alphonso mangoes showed significantly decreasing trend with the passage of storage period when stored at 32-36^{o}C and RH of 70-75%. Low sensory score (66.70) was observed at first day as compared to control samples having higher score (79.5) after 8 days of storage due to the fact that mangoes started ripening.

References

Amin, M and M. Hanif, 2002. Cultivation of mango in Dera Ismail Khan. Agri. Res. Institute. Ratta, D.I. Khan, pp: 1-18.

AOAC, 1994. Official Methods of Analysis. Association of Official Analytical Chemists. 1111 North 19th Street, Suite 20, 16th Edi. Arlington, Virginia, USA. 22209.

Doreyappy-Gowda, I.N.D and A.G. Huddar, 2001. Studies on ripening changes in mango (*Mangifera indica L.*) fruits. J. Food Sci. Tec. Mysore, 38: 135-137.

Carrillo, L.A., F. Ramirez-Bustamante, J.B. Valdez-Torres, R. Rojas-Villegas and E.M. Yahia, 2000. Ripening and quality changes in mango fruit as affected by coating with an edible film. J. Food Qlty, 23: 479-486.

Haq, A., 2002. Pasckage for mango production, post harvest techniques and its export prospects, Mango Res. Inst. Shajabad, pp: 1-15.

Hayat, I., T. Masud and H.A. Rathore, 2005. Effect of coating and wrapping materials on the shelf life of apple (*Malus domestica cv. Borkh).* Int. J. Food Safety, 5: 24-34.

Herianus, J.D., L.Z. Singh and S.C. Tan, 2003. Aroma volatiles production during fruit ripening of 'Kensington Pride' mango. Postharvest Biol. Tec., 27: 323 -336.

Kays, S.J., 1991. Post harvest Phys. of Perishable Plant Products. Vas Nostrand Rein Hold Book, AVI Publishing Co, pp: 149-316.

Kittur, F.S., N. Saroja, Habibunnisa and R.N. Tharanathan, 2001. Polysaccharide-based composite coating formulations for shelf-life extension of fresh banana and mango. Eur. Food Res. Tec. 213: 306-311.

Kudachikar, V.B., S.G. Kulkarni, M.N.K. Prakash, M.S. Vasantha, B.A. Prasad and K.V.R Ramana, 2001. Physico-chemical changes during maturity of mango *(Mangifera indica L.)*Variety "Neelum" J. Food Sci. Tec. Mysore, 38: 540-542.

Larmond, E., 1977. Laboratory Methods of Sensory Evaluation of Food Research Branch Canada . Deptt . Agri . Publication, P: 44.

Malik, A.U., Z. Singh and S.S. Dhaliwal, 2003. Exogenous application of putrescine affects mango fruit quality and shelf life. Acta Hort., 628: 121-127.

Malundo, T.M.M., R.L. Shewfelt, G.O. Ware and E.A. Baldwin, 2001. Sugars and acids influence flavor properties of mango *(Mangifera indica)*. J. Am. Soc. Hort. Sci., 126: 115-121.

Manzano, J.E., Y. Perez and E. Rojas, 1997. Coating waxes on Haden mango fruits (*Mangifera indica* L.) cultivar for export. Acta Hort., 455: 738-746.

McWilliam, M., 1989. Food experimental perspectives. Macmillan publishing company. Inc. USA., 217pp.

Mortuza, M.G and M.M.A. Reza, 2001. Control of postharvest anthracnose and stem-end rot of mango fruits by hot water treatment. Bangladesh J. Agri. Res., 26: 543-548.

Narayana, C.K., R.K. Pal and S.K. Roy, 1996. Effect of pre-storage treatments and temperature regimes on shelf-life and respiratory behaviour of ripe Baneshan mango. J. Food Sci. Tec. Mysore, 33: 79-82.

Opara, L.U., H.X. Nguyen and Levanto, 2000. Postharvest technology for Vietnamese Buoi mango. Quality assurance in agricultureal produce. ACIAR proceedings, 100: 633-638.

Pal, R.K., 1998. Ripening and rheological properties of mango as influenced by ethrel and calcium carbide. J. Food Sci. Tec. Mysore, 35: 358-360.

Perez, K., J. Mercado and H.S. Valdez, 2004. Effect of storage temperature on the shelf life of Hass avocado (Persea Americana). Food Sci. Tec. Int., 10: 73-77.

Raje, L., S. Sherlekar, K. Ramakrishnan, V.C. Malshe and G. Subbulakshmi, 1997. Post harvest preservation of mangoes by controlled chemical release agents and adsorbent. Acta Hort., 455: 622-628.

Rodov, V., S. Fishman, R.D. Asuncion, J. Peretz and S.B. Yehoshua, 1997. Modified atmosphere packaging (MAP) of Tommy Atkins mango in perforated film. Acta Hort., 455: 654-661.

Sauco, V.G., 2002. Magazine of Chronica Horticulturae. Int. Soc. Hort. Sci., 42: 14-17.

Srinivasa, P.C., R. Baskaran, M.N. Ramesh, K.V.H. Prashanth and R.N. Tharanathan, 2002. Storage studies of mango packed using biodegradable chitosan film. Eur. Food Res. Tech., 215: 504-508.

Steel, R.G.D and J.H. Torrie, 1980. Principles and Procedures of Statistics. Mc Graw Hill Book Co. Inc. New York, P: 134-145.

Tahir, F.M., M.A. Pervaz and C. Hameed, 2002. Losses of mango fruit after harvest and its control. Agri. Digest, 37: 62-64.

Weichmann, J., 1987. Post Harvest Physiology of Vegetables. Marcel Bekker, Inc, New York, P: 145.

Wills, R.B., T.H. Lee, D. Graham, W.B. Glasson and E.G. Hall, 1982.Post harvest: An Introduction to the Phys. and Handling of Fruits and Vegetables. AVI Publishing Co., Westport, P: 34-35.

Yahia, E.M. and M.T. Hernandez, 1993. Tolerance and responses of harvested mango to insecticide low-oxygen atmosphere. Hort. Sci., 28: 1031-1033.