PHYSICO-CHEMCIAL QUALITY OF APPLE CV. GALA MUST FRUIT STORED AT LOW TEMPERATURE

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Abstract

Apple cultivar 'Gala must' was stored at 10±2 ^{o}C and 80-85% relative humidity and evaluated for physico-chemical quality and attributed at 30, 60, 90, 120 and 150 days storage intervals. Apple storage resulted an increase in the rate of weight loss with increasing storage duration and thus the maximum weight loss (1.24%) was recorded with 120 days storage period. The flesh firmness declined from the maximum (7.03 kg cm^{-2}) in fresh fruits to the minimum of 4.31 kg cm^{-2} with storage for 150 days. Increasing storage duration increased the total soluble solids content from 17.0% in fresh fruits to 19.06% in fruits stored for 150 days. The fruit pH and the percent reducing sugars increased from 3.47 to 3.68 and 10.0 to 11.93 when storage was extended from 0 to 150 days, respectively, but the non-reducing sugars declined significantly from the maximum of 3.20% to the minimum of 1.45% during the storage for 150 days. Organolyptic quality test revealed that different quality attributes such as taste, color and texture declined with storage resulting in decreased overall acceptability score from 7.23 in fresh fruits to 6.56 with 120 and 150 days storage respectively.

Introduction

The apple fruit technically known as *Malus malus* and belongs to the family Rosaceae. Apple is the leading fruit of the temperate regions of the world. It originated in south western Asia and spread throughout the world. In Pakistan, the total area under apple orchards during 2008-09 was 113029 hectares with total production of 441062 tones, while in Khyber Pakhtunkhwa the apple is grown over an area of 9685 hectares which contributed 130820 tones to the national apple production (MINFAL, 2008-09). In Khyber Pakhtunkhwa province, Swat region is the major apples producing region, where apple orchards occupy 4180 hectares that produced 49910 tones (MINFAL, 2006-07). The apple is a good source of food and nutrition (Hussain, 2001) and is in high demand throughout the year and hence is generally stored. Apple fruit is generally harvested during the month of August and September and much of the harvested fruit is supplied to the markets for fresh consumption, but the prices are generally low during the harvesting season (Ali *et al.*, 2004). Thus, storage is required to catch good market price and ensure its supply during the off-season. The apple is climacteric fruit and hence its quality declines after harvest due to respiration and ethylene production (Kader, 2002). In relatively cooler climates, simple warehouses can be used for storing apples, but cold storage is required for long term storage and quality retention (Mitropoulos and Lambrinos, 2000). The storage life of apple is extended by storing at 30 to 32°F (Bridgette and Tong 2008). Being a perishable commodity, the apple fruit is prone to postharvest losses that may range from 25-40% (Raja & Khokhar, 1993). Besides quantitative losses, the loss of chemical quality and texture is also a serious problem in stored apples (Kov and Felf, 2003). The fruit besides post harvest, the softening of apple during storage is one of the most important problems all over the world. Increasing the storage temperature enhances the rate of decline in quality and thus increase storage losses in apple fruit. According to Shah *et al* (2002) about 17% of apples produced in Balochistan are lost during postharvest operations, while Ilyas *et al* (2007) reported about 28% losses in apple fruit with cold storage for 22 weeks. Postharvest losses may also depend on production area and market distance and the mode of transportation (Ilyas *et al.*, 2007). Considerable variations have been reported in the storage potentials of different cultivars and the loss of quality during storage (Rutkowski *et al.*, 2008). The study was therefore, carried out to assess the quality and post harvest losses of apples cultivar Gala Must, stored at refrigerated temperatures in cold storage.

Materials and Methods

The experiment was carried out in Khyber Pukhtonkhwa Agriculture University, Peshawar. Apples were procured from District Bagh, Azad Jammu and Kashmir. The apple fruits were kept in refrigerator ($\pm$10^{o}C) for storage. Different parameters were studied on apple fruits with the interval of 30 days.

Statistical analysis: The whole data was analyzed by using complete randomized design (CRD) and means were separated by using least significant difference (LSD) test as prescribed by Steel and Torrie (1984).

Pulp extraction: Pulp of apple fruit was extracted with the help of fruit juice by cutting the fruit into pieces with the help of a stainless steel knife.
The following parameters were studied during the experiment.

The rate of weight loss (% weight loss/month): Five fruits were separately packed for each treatment and replication. They were weighed before storage and at the end of each storage interval. The rate of weight loss was estimated by the initial and final weight for each interval and converted to percent weight loss / month by the formula:

$$\text{Fruit weight loss (\%)} = \frac{\text{Initial weight} - \text{final weight}}{\text{Initial weight}} \times 100$$

Fruit firmness (kg cm^{-2}): Flesh firmness of peeled tissue was measured on both sides of each apple with Effegi (1979) penetrometer fitted with 11 mm diameter prob.

Total soluble solids (TSS): Total soluble solids (TSS) were determined by the method of Association of official analytical chemists (A.O.A.C, 1984) by using Abbe Hand Refractometer at room temperature. The extracted juice was shaken well by a shaker. The representative sample of a well shaken juice was placed (drop) on a absolutely dry Refractometer Prism and the reading was taken directly and necessary temperature correction was made.

Juice pH: The pH of the juice was determined with Inolab digital pH meter after prior calibration with standard pH solutions.

Sugars: Reducing sugars and non-reducing sugars were determined by Lane Eynone Method (A.O.A.C, 1984). For this purpose, 10 fruits from each treatment and in each replication were taken at random. The juice was extracted from the fruit with the help of locally made juice extractor and 25 grams of filtered (Whattman-4) juice was transferred to 250 ml volumetric flask. 100 ml of distilled water was added to it and neutralized with 1N NaOH and then 2 ml of lead acetate solution was added, solution shaken and let it to stand for 10 minutes. The necessary amount of potassium oxalate was added to remove the excess lead and the volume made with distilled water.
Sugars were calculated as:

a. $\%\ \text{Reducing sugars} = \frac{\text{Factor} \times \text{dilution} \times 100}{\text{titre x Wt or volume of the sample}}$

b. Non-reducing sugars = (% total sugars - % reducing sugars) x 0.95

Care was taken to prepare fresh Fehling A and B solutions each time when the sugars determinations were made from the samples.

Organoleptic test and Overall Quality: A panel of ten referees was selected for the organoleptic test. The panel evaluated apple fruit for various organoleptic qualities attributes such as fruit color, taste and texture by scoring 1 to, 9 where 1 was given for like extremely, 2 for like very much, 3 for like moderately, 4 for like slightly, 5 for neither like nor dislike, 8 for dislike slightly, 7 for dislike moderately, 8 for dislike very much and 9 for dislike extremely as suggested by hedonic scale (Ashaye *et al*., 2005). The values for color taste and texture score were then averaged to determine the overall quality of apple fruit.

Results and Discussions

Rate of weight loss/ month (%): The rate of weight loss was the least initially (0.61%/month), that increased significantly to 1.24, but declined back to 0.63 percent/month with 120 and 150 days storage, respectively. The fruit continue to lose water after harvest resulting in increased weight loss (Al-Obeed and Horhash 2006). It has been reported earlier that percent weight loss generally increased with increasing storage duration. The weight loss in fruit depends on the nature and amount of waxy on the surface of the fruit (Veravrbeke *et al*., 2003). Thus, the relative low rate of weight loss for up to 90 days of storage indicated that the waxy layer may have been in-tact for 90 days and damage to this layer with 120 days storage could may the major reason responsible

for high weight loss during this period (Gavlheiro *et al*., 2003). The loss of moisture and subsequent weight loss also depends on the water content of the fruit (Banarus *et al*., 1994). Thus, the declined in weight loss with 150 days storage may due to low water content of the fruit and not allowing rapid moisture loss from the fruit (Karathanos, 1999).

Table 1. Effect of storage duration on relative weight loss/month, fruit firmness and the total soluble solids content of apple fruit.

Storage intervals (days)	RWL (%)	Firmness (kg cm^{-2})	TSS (^{o}Brix)
0 (Initial)	ND*	7.03 a	17.00 d
30	0.61 d	6.11 b	17.33 d
60	0.73 c	5.67 bc	17.67 cd
90	0.87 b	5.07 cd	18.33 bc
120	1.24 a	4.63 de	18.67 b
150	0.63 d	4.31 e	19.67 a
LSD (0.05)	0.020	0.724	0.937

Table 2. Effect of storage duration on pH, reducing sugar (%) and non-reducing sugar (%).

Storage intervals (days)	pH	Reducing sugar (%)	Non-reducing sugar (%)
0 (Initial)	3.68 a	10.0 d	3.20 a
30	3.62 b	10.37 c	3.03 a
60	3.61c	10.93 b	2.76 b
90	3.58d	11.23 b	2.20 c
120	3.51e	11.65 a	1.84 d
150	3.42 f	11.93 a	1.45 e
LSD (0.05)	0.0133	0.3046	0.2255

*** Not Detected**

Table 3. Mean score of judges for color, taste, texture and overall acceptability of apple.

Sensory attributes	Storage intervals					
	Initial	30	60	90	120	150
Color	6.68a	7.00a	6.68a	7.00a	6.68a	6.68a
Taste	7.33a	7.00a	7.00a	6.67ab	6.67ab	6.67a
Texture	7.67a	7.33ab	6.67ab	6.33b	6.33b	6.33b
Overall Acceptability	7.23a	7.11a	6.78b	7.00a	6.56b	6.56b

Fruit firmness (kg cm^{-2}): The maximum flesh firmness (7.03) was recorded in fresh fruits, which declined to the minimum 4.31 kg cm^{-2} with 150 days storage at low temperature. Fruit firmness is an important criteria for fruit quality of apples (De-Ell *et al*., 2001; Weibel *et al*., 2004) and the loss of fruit firmness is a serious problems in postharvest handling of apple fruits (Kov and Felf, 2003), because it resulted in soft and mealy fruit with poor consumers acceptance. Rapid post harvest softening of apple was caused by water loss due to transpiration and cell wall breakdown due to enzymatic activities (Kweon *et al*., 1998). While the water loss was related to influence on the turgidity of the cells (Ghafir *et al*., 2009) and subsequent stiffness of apple fruit, while the cell wall changes influence the firmness of the apple fruit by reducing the mechanical strength of cell walls (Chang-Hai *et al*., 2006). These changes may be involved the disassembly of primary cell wall and middle lamella structures (Fuller, 2008), thus, reducing the mechanical strength of cell walls which decreased the firmness in apple fruits (Kov *et al*., 2003).

Total soluble solids (^{o}Brix): The total soluble solids (TCS) content of apple fruit was significantly affected by storage duration. The minimum TSS content (17.0% was recorded in fresh fruits which increased significantly with storage duration to the maximum of 19.06% with storage for 150 days. The total soluble solids of apple and

other fruits was an important quality factor and was used in TSS/Acid ratio (Weibel *et al*., 2004). Total soluble solids, generally increased during storage (Mahajan, 1994). The increased in TSS could be attributed to the breakdown of starch into sugars. Since, TSS percentage was a function of total dissolved solids and moisture content of the fruit, the increased in TSS could also be due to low moisture content of the fruit or the concentration of soluble solids due to moisture loss.

Fruit pH: Data regarding pH are presented in Table.2 revealed significant ($p \leq 0.05$) differences in pH with the storage duration. The pH of the apple fruits increased from 3.68 to 3.47. Since the pH of the fruit is mainly due to the organic acids present in the fruits which are consumed in respiration, it was likely to observe an increase in the pH of the fruit (Ghafir *et al*., 2009).

Reducing sugars: The reducing sugars revealed the significance difference ($p \leq 0.05$) in reducing sugars with different storage duration. The reducing sugars increased from the lowest (10.0%) in fresh fruits to the maximum of 11.93 with 150 days storage at low temperature. It has been reported by Bajwa *et al.* (2003), that there was an increase in glucose and fructose contents in water melon during storage. The apple fruit generally accumulated starch during its development which served as stored carbohydrates and was hydrolyzed to reducing sugars at edible maturity (Magein and Leurquin, 2000). The conversion of starch to sugars continued during storage and hence the total and reducing sugars content were increased with storage duration. Reducing sugars represented the main non-structural carbohydrate of fruit (Raimundo *et al*., 1996).

Non-reducing sugar (%): The non-reducing sugars of apple were significantly affected ($p \leq 0.05$) by storage duration. The highest non reducing sugars recorded in fresh fruit 3.20% declined significantly to 1.45% during 150 days storage at low temperature. In apple fruit, the starch was the predominant carbohydrates and it generally declined with toward maturation and during storage (Magein and Leurquin, 2000). Similarly, the soluble non-reducing sugars such as sucrose may also be consumed in the respiration, it was likely top observe decreased non- reducing sugars with increasing storage duration. (Riaz *et al.*, 1999).

Overall acceptability: Statistical analysis for overall acceptability showed significant difference at ($p \leq 0.05$). The maximum mean score was (7.23) and minimum (6.56) at initial and 120^{th} and 150^{th} days of storage interval. Overall acceptability of fruit decreased as the storage prolonged. Over acceptability played an important role in the produce development. The apple fruit continued to respire and hence was decrease in quality despite low temperature (Kader, 2002). The loss of moisture content (Karathanos, 1999), firmness (Gomez *et al*., 1998) as well biochemical changes (Ghafir *et al*., 2009) influenced the texture and taste as well as the visual quality of the fruit with increasing storage duration.

Conclusions

The apple fruit of cultivar Gala Must showed significant increased in the rate of fruit weight loss with the peak weight loss rate observed at 120 days storage interval. The biochemical changes showed increased pH and reducing sugars, but decreased in non-reducing sugars with the increasing storage duration. The organoleptic test results almost coincided with the weight loss and has indicated that the storage at 10±2°C should not be extended to 120 days in order to avoid the rapid quality losses in the apple fruit.

References

Al- Obeed, R.S. and Harhash, M.M. (2006). Impact of postharvest treatments on storage life and quality of "Mixican" Lime. *J. Adv. Agric. Res.* 11(3): 533-549.

Ali, M.A., Raza, H., Khan, M.A. and Hussain, M. (2004). Effect of different periods of ambient storage on chemical composition of apple fruit. *International Journal of Agriculture & Biology* 3: 568-571.

A.O.A.C. (1984). Association of Official Analytical Chemists. Official Method for Analysis, Washington D.C.

Ashaye, O.A., Babalola, S.O., Babalola, A.O., Aina, J.O. and Fasoyiro, S.B. (2005). Chemical and Organoleptic Characterization of Pawpaw and Guava Leathers *World Journal of Agricultural Sciences* 1: 50-51.

Bajwa, E.E., Naeem, Z., Anjum, J. and Nazir. (2003). Development, standardization and storage studies on watermelon-lemon. *Pak. J. Food Sci.* 12: 21-24.

Banarus, M., Lownds, N.K. and Bosland, P.W. (1994). Relationship of physical properties to postharvest water loss in pepper fruit (*Capsicum annuum* L.). *Pak. J Bot.* 26: 321-26

Bridgette and Tong, C. (2008). Commercial post harvest handling of fresh market apples. University of Minnesota.

Chang- Hai, J.I.N., Biao, S.U.O., Juan, K., Mei, W.H. and Jun, W.Z. (2006). Changes in cell wall polysaccharide of harvested peach fruit during storage. *Journal of Plant Physiology and Molecular Biology* 32: 657-664.

De-Ell, J.R., Khanizadeh, S., Saad, F. and Ferree, D.C. (2001). Factors affecting apple fruit firmness. *J. Am. Pomol. Soc.* 55: 8-27.

Effegi. (1979). Determination and control of physical properties of food material Rla CEd. D. Redielishing Co., Dordrecht, Holand, P. 131.

Fuller, M.M. (2008). The ultrastructure of the outer tissues of cold-stored apple fruits of high and low calcium content in relation to cell breakdown. *Annals of Applied Biology* 83: 299-304.

Gavalheiro, O.J., Santos, A., Recasens, I., Larriganciere, C. and Silvestre, A. (2003). Quality of the postuguese 'Bravo de Esmolfe' apple after normal cold storage or controlled atmosphere and two shelf life periods. *Acta Horticulture* 1: 395-400.

Ghafir, S.A.M., Gadalla, S.O., Murajei, B.N. and El-Nady, M.F. (2009). Physiological and anatomical comparison between four different apple cultivars under cold-storage conditions. Afri. *J. of Pl. Sci.* 3: 133-138.

Hussain, T. (2001). Food composition table for Pakistan. Govt. of Pakistan, Ministry of P & D Islamabad, Pakistan.

Ilyas, M.B., Ghazanfar, M.U., Khan, M.A., Khan, C.A. and Bhatti, M.A.R. (2007). Post harvest losses in apple and banana during transport and storage. *Pak. J. Agri. Sci.* 44(3): 534.

Kader, A.A. (2002). Postharvest Technology of Horticultural Crops. 3rd ed. University of California, Oakland, Extension Publication pp. 296.

Karathanos, V.K. (1999). Determination of water content of dried fruits by drying kinetics. *Journal of Food Science and Engineering* 39: 337-344

Kov, E. and Felf, E. (2003). Investigating the firmness of stored apples by non-destructive method. Acta Hort. (ISHS) 59: 257-260.

Kweon, H., Yul, K.H., Park, R.O. and Youn, M. (1998). Effects of CA storage procedures and storage factors on the quality and the incidence of physiological disorders of "Fuji" apples. *Journal of the Korean Society for Horticultural Science* 39(1): 35-39.

Magein, H. and Leurguin, D. (2000). Changes in amylase, amylopectin and total starch content in 'Jonagold' apple fruit during growth and maturation. *Acta Hortic.* 517: 487-491.

Mahajan, B.V.C. (1994). Biochemical and enzymatic changes in apple during cold storage. *J Food Sci. Technol*. 31:142-144.

MINFAL. (2008-2009). Ministry of Food, Agriculture and Livestock.

MINFAL. (2006-2007). Agriculture Statistics of Pakistan. Ministry of Food, Agriculture and Livestock, Government of Pakistan, Islamabad Pakistan.

Mitropoulos, D. and Lambrinos, G. (2000). Dehydration of "Delicious Pilafa" and Granny Smith apple during storage. In Proceedings of the Second Agricultural Engineering National Congress, Giaxoudi-Giapouli, Volos, Greece. 1. pp: 433-440.

Raimundo, S., Barros, R.S., Finger, F.L. and Magalhaes, M.M. (1996). Changes in non-structural carbohydrates in developing fruit of Myrciaria jaboticaba . *Scientia Horticulturae* 66: 209-215.

Raja, M.B. and Khokhar, K.M. (1993). Postharvest horticulture technology and its future prospects, pp: 265-277. .In: *Proceeding of first international horticulture seminar* 09-11.

Riaz, M.N., Muhyuddin, G. and Al Haq, M.I. (1999). Physical chemical and sensory characteristics of jams made from fresh and frozen strawberries. *Pak. J. Arid Agric.* 2(1): 51-60.

Rutkowski, K., Michalzuk, P.B. and Konopacki, P. (2008). Nondestructive determination of 'Golden delicious' apple quality and harvest maturity. *Journal of Fruit and Ornamental Plant Research* 16: 39-52.

Shah, N.A., Khan, S., Kasi, M.A. and Khair, S.M. (2002). Post harvest and cold storage losses in apple of Balochistan. *Asian Journal of Plant Sciences* 1(1): 65-66.

Steel, R.G.D., Torrie, J. H., (1984). Principles and Procedures of Statistics. McGraw Hill Book Co. Inc., London.

Veravrbeke, E.A., Verboven, P., Oostveldt, P. and Nicolai, B.M. (2003). Predication of moisture loss across the cuticle of apple (*Malus sylvestris* supsp. *Mitis* (Wallr.) during storage: part 2. Model simulations and practical applications. *Postharvest Biol. Technol.* 30: 89-97.

Weibel, F., Widmer, F. and Husistein, A. (2004). Comparison of production systems: integrated and organic apple production. Part III: Inner quality: composition and sensory. Obst-und Weinbau. 140: 10-13.