The Journal of Animal & Plant Sciences, 21(1): 2011, Page: 38-41
ISSN: 1018-7081

POST-HARVEST PHYSICOCHEMICAL CHANGES IN FULL RIPE STRAWBERRIES DURING COLD STORAGE

A. Ali, M. Abrar, M. T. Sultan*, A. Din and B. Niaz

Post-harvest Research Centre, Ayub Agricultural Research Institute, Faisalabad
*Department of Food Sciences, Bahauddin Zakariya University, Multan.
Corresponding author: tauseefsultan@bzu.edu.pk

ABSTRACT

The objective of the present research was to study the post-harvest changes in quality attributes of fully ripened strawberry fruit during cold storage. The research trial was conducted using three different temperatures i.e. (0ºC, 5ºC and 10ºC) with 90-95% relative humidity. Quality attributes studied include firmness; weight loss, total soluble solids, pH and acidity during 2 weeks of storage after three days interval. The results indicated that titratable acidity and pH were affected non-significantly as a function of storage conditions. Whereas, weight loss was rapid in the samples stored at room temperature and 10°C than those stored at 0°C. It was further observed that at 0° C strawberry fruit showed maximum shelf life. Additionally, quality attributes remained stable as compared to 5°C and 10°C. The results indicated that fully ripened strawberry fruits should be stored at 0°C to retain best quality under climatic conditions prevailing in Pakistan.

Keywords: Post-harvest management, strawberry, physicochemical changes, weight loss, shelf life

INTRODUCTION

Strawberries (*Fragaria ananassa*) are highly perishable commodity and characterized by a short shelf life (Han *et al.,* 2005). The strawberry fruit is gaining wide range of popularity in Pakistan and mostly imported from western countries. It is known non-climatic fruit of frequent human consumption and Europe is its largest producer over the globe (Avigdori-Avidov, 1986; Manning, 1993). Strawberry is very susceptible to mechanical injury, water loss, decay and physiological deterioration after harvesting, thus reducing the profit margin of the stake holders. Moreover, quality attributes of fruits also deteriorates with the passage of time, thus rendering unsafe product for the consumers. In this context, Woodward (1972) suggested that fruit should be harvested immediately after the white stage in order to develop color after harvest similar to commercially ripened fruit. Although the physical and/or chemical changes in harvested strawberries during storage have been the subject of several other studies, only the storage effects on completely white or fully colored strawberries were considered and those studies did not include comparisons with the changes occurring in fruit ripening on the plant at different climatic conditions.

The objective of the present study was to study the post-harvest physiology of strawberry fruit during storage at different storage conditions.

MATERIALS AND METHODS

Procurement of raw material: The physiologically mature strawberry fruits of Sweet Charlie variety were harvested from Sharakpur Orchard, situated in Punjab province of Pakistan. Sorting and grading was carried out. The homogenous samples of uniform, similar size and weight were isolated from the diseased, bruised and irregular shaped fruit and selected for further studies.

Washing with anti microbial solution: The harvested strawberry was brought to Research Laboratory of Post Harvest Research Centre, Ayub Agricultural Research Institute, Faisalabad. Samples were washed with sodium hypochlorite solution to keep safe from microbial contamination.

Storage conditions: Strawberries were stored at three different temperatures i.e. 0º C, 5º C and 10º C with 90-95% relative humidity. Different quality parameters. (firmness; weight loss, total soluble solids, pH and acidity) were observed during 2 weeks of storage.

Physicochemical tests

Firmness: Firmness was determined at the equatorial part of each strawberry fruit with a PCE-PTR 200 penetrometer after 0, 3, 6, 9, 12 and 15 days of storage.

Weight loss (%): Weight loss percent was measured after 0, 3, 6, 9, 12 and 15 days. The weight measured (Digital Electrical Balance) at zero days was taken as reference weight and calculated by using following formula:

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

pH: pH was determined with a pH meter (WTM: Model inoLab 720), which had been previously standardized to pH 7.

Total soluble solids: Total soluble solids (TSS) were determined through a refractometer (Abbe Refractometer Model 2WAJ) after 0, 3, 6, 9, 12 and 15 days.

Acidity: Titratable acidity was determined by titration with 0.1 N NaOH with an automatic titrimeter (Fisher Scientific Co., Pittsburgh, Pa.). The results were converted to percent citric acid [(ml NaOH x 0.1 N x 0.064/6.00 g of juice) x 100] and expressed in terms of fresh weight.

Statistical analysis: The data obtained was statistically analyzed through Two-way Analysis of Variance technique and means differing significantly were compared using LSD (least significant difference) test (Steel *et al*., 1997)

RESULTS AND DISCUSSION

Firmness: Firmness of the strawberry fruits is one of the vital quality attribute. It was observed from the present research intervention that firmness decreased as a function of storage time. However, firmness was decreased slowly in strawberries stored at 0º C i.e. 0.86 to 0.41 (grams/ mm). In comparison, the firmness of strawberries decreased at higher rates at 5º C firmness and it decreased to 0.42 (grams/ mm) after 6 days only.

Previous studies also proved that strawberry firmness decreases either during ripening in the field or during storage regardless of the initial ripeness of the fruit (Nunes *et al*; 2006). According to Koh and Melton (2004) softening of strawberry fruit, either during ripening in the field or during storage is mainly due to loss of cell wall material. Softening of strawberry is mainly due to the presence of polygalacturonase which solubilizes and degrades the cell wall polyuronides (Huber, 1984; Nogata *et al* 1993). In contrast, some studies depicted consistency in firmness was maintained, or even increased, at 0, 5 or 10 C. (Youngjae *et al;* 2007)

Weight loss: Weight loss was 8.6% in 3 days in the control sample while at 0º C it was 6.4% after 15 days as compared to (5ºC) where it was 5.3% in 6 days. Previous studies reported that weight loss of fruit was found to be negligible for 2 days at 0°C and 10°C but it increased at 10 C and increased rapidly from day 3 at 20 C (Youngjae *et al*; 2007).

pH: pH of ripened strawberries during storage did not change significantly from that at the time of harvest, regardless of the initial color stage of the fruit (Cecilia *et al*., 2006). pH of all cultivars ranged between 3.6 and 4.1, values that were above the average for ripe strawberry, pH of 3.3 (Green, 1971). Cordenunsi *et al.,* (2005) reported that no significant changes in pH were observed during storage of the fruits for 6 days at 6 ºC. Again, the exception was 'Toyonoka' cultivar, which showed a decrease of pH from 4.1 to 3.8. According to Olsson *et al*., (2004) there was decrease in the pH content of ripe dark red strawberries after 3 days at 4 °C. In the present study it was observed that pH was almost stable during storage in all treatments. So the low temperature used to store the fruit has contributed to a stabilization of the pH of the fruit throughout storage.

Total soluble solids: In the present study it was observed that TSS is decreasing in the control sample. While in the second treatment it was 5.6 at 1st day and 5.40 at 3rd day and at 14th day it was 5.0. And in third treatment trial was continued only up to six days and at that day TSS was 5.3. Cordenunsi *et al*. (2005) reported an increase of up to 30% in the total soluble sugars of full-size, three-quarters red strawberries during storage at 6 °C for 6 days. Reyes *et al*., (1982) observed a decline in soluble solids in overripe strawberries. They reported that soluble solids of strawberries remain the same or increase during storage. After 8 days at 1^{o}C, the soluble solids concentration (SSC) of half mature strawberries was found to be lower than that of fruit at the time of harvest.

Brix shows slight variations in the first stages of sampling without significant differences, increasing sharply from day 21 after fruit set, when fruit ripening seems to start. The maximum content of soluble solids was seen after approximately 28 days, decreasing significantly from that time. The increase in soluble solids when ripening occurs was described by Salunkhe and Desai (1984) in other strawberry varieties.

Soluble solids concentrations (SSC) decreased at higher storage temperatures. (Youngjae *et al*., 2007).

Acidity: Titratable acidity has been expressed as milligrams of citric acid per gram of fresh weight. According to Shamaila *et al*. (1992), this is the most abundant acid present in strawberry fruit. Acidity declines as fruit mature. It could be considered that fruits start to ripen after 21 days from fruit set. Spayd and Morris (1981) found that total acidity increases modestly to a maximum in mature green fruit before declining more rapidly in the later stages of ripening.

The percentages of titratable acidity (TA), in Sweet Charlie variety were between 0.6 and 0.7 during the storage period. These values are close to the lowest value mentioned in the literature, between 0.6 and 2.3% (Green, 1971; Montero *et al*., 1996).

According to Nunes *et al*. (1995), cultivars 'Chandler', 'Oso Grande' and 'Sweet Charlie', stored at 1°C, showed no differences in pH, but TA was slightly lower after 1 week.

In the present study, it was observed that in samples stored at 0ºC, acidity was increasing gradually during storage while samples stored at 5º C were retained only up to six days so samples stored at 0ºC showed maximum shelf life. Green, (1971) observed no marked changes in citric acid content during fruit storage at cool temperature. His results are in concordance with the results obtained for pH as all cultivars ranged between 3.6 and 4.1 for their pH value. However, the observed valued were slightly higher than ripe strawberry i.e. pH of 3.3.

Table 1: Study of Firmness (Kg) in strawberry fruit during storage

Temperature	Storage intervals (days)					
	0	3	6	9	12	15
0ºC	0.85a	0.61cd	0.32f	0.19g	0.14g	0.05h
5ºC	0.86a	0.75b	0.67c	0.53d	0.45e	0.41e
10ºC	0.80ab	0.56d	0.42e	0.28f	0.16g	0.10gh

* The values with similar Lettering differ no-significantly from each at 5% level of significance

T_1, (control) Strawberries stored at 10°C, T_2, Strawberries stored at 5°C temperature, T_3, Strawberries stored at 0°C temperature

Table 2: Study of Weight loss (%) changes in strawberry fruit during storage

Temperature	Storage intervals (days)					
	0	3	6	9	12	15
0ºC	0	8.6b	10.4ab	11.8a	12.6a	13.4a
5ºC	0	0.5d	1.3d	1.6d	2.1d	6.4c
10ºC	0	0.6d	1.3d	1.8d	2.1d	7.3c

* The values with similar Lettering differ no-significantly from each at 5% level of significance

T_1, (control) Strawberries stored at 10°C, T_2, Strawberries stored at 5°C temperature, T_3, Strawberries stored at 0°C temperature

Table 3: Study of pH in strawberry fruit during storage

Treatments	Storage intervals (days)					
	0	3	6	9	12	15
T_1	3.78b	3.76b	-	-	-	-
T_2	3.75b	4.06a	4.05a	-	-	-
T_3	3.80b	4.05a	4.05a	3.99a	4.0a	4.04a

* The values with similar Lettering differ no-significantly from each at 5% level of significance

T_1, (control) Strawberries stored at 10°C, T_2, Strawberries stored at 5°C temperature, T_3, Strawberries stored at 0°C temperature

Organic, non-volatile acids are the second most important component of strawberry flavor, after soluble sugars. The main compound accounting for titratable acid (TA) is citric acid, which is predominant (over 90%) in strawberry. These acids regulate the cellular pH and may influence the anthocyanin stability and, as a consequence, the color of the fruit. Overall there are very slight changes in pH and acidity of strawberry fruit during storage at low temperature. (Cordenunsi *et al., 2005*)

Table 4: Study of Total soluble solids in strawberry fruit during storage

Temperature	Storage intervals (days)					
	0	3	6	9	12	15
0ºC	5.70ab	4.20e	-	-	-	-
5ºC	5.8ab	6.0a	5.3cd	-	-	-
10ºC	5.60bc	5.40bc	5.30cd	5.40bc	5.20de	5.0de

* The values with similar Lettering differ no-significantly from each at 5% level of significance

T_1, (control) Strawberries stored at 10°C, T_2, Strawberries stored at 5°C temperature, T_3, Strawberries stored at 0°C temperature

Table 5: Study of Acidity in strawberry fruit during storage

Temperature	Storage intervals (days)					
	0	3	6	9	12	15
0ºC	0.62c	0.78b	-	-	-	-
5ºC	0.66c	0.48d	0.45d	-	-	-
10ºC	0.65c	0.94a	1.00a	0.95a	0.85ab	0.94a

* The values with similar Lettering differ no-significantly from each at 5% level of significance

T_1, (control) Strawberries stored at 10°C, T_2, Strawberries stored at 5°C temperature, T_3, Strawberries stored at 0°C temperature

Conclusion: The results indicated that low temperature, used to increase strawberry shelf life, could also induce small changes in some of the quality parameters studied. Another important point arising from the results is that cold storage is an efficient way to preserve strawberries, since no deleterious changes were observed either sensorial or nutritionally, at least considering the parameters above.

REFERENCES

Avigdori-Avidov, H. (1986). Strawberry. In: S.P. Monselise (Editor), Handbook of Fruit Set and Development. CRC Press, Boca Raton, pp. 419-448.

Cecilia, N.N., K.B. Jeffrey, M.M.B.M. Alcina, and A.S. Steven (2006). Physicochemical changes during strawberry development in the field compared with those that occur in harvested fruit during storage. J. Sci. Food Agric. 86: 180–190.

Cordenunsi, B.R., M.I. Genovese, J.R.O. Nascimento, N.M.A. Hassimotto, R.J. Santos, and F.M. Lajolo (2005). Effects of temperature on the chemical composition and antioxidant activity of three strawberry cultivars. *Food Chem.* 91: 113–121.

Green, A. (1971). Soft fruits. In Hulme A. C. (Ed.), The biochemistry of fruits and their products. New York Academic Press. pp. 375–410.

Han, C., C. Lederer, M. Mcdaniel, Y. Zhao (2005). Sensory Evaluation of Fresh Strawberries (Fragaria ananassa) Coated with Chitosan-based Edible Coatings. Journal of Food Science**,** 70: 172 - S178.

Hubert, D. J. (1984). Strawberry Fruit Softening: The Potential Roles of Polyuronides and Hemicelluloses. Journal of Food Science, 49(5): 1310–1315.

Koh, T.H., and L.D. Melton (2004). Ripening-related changes in cell wall polysaccharides of strawberry cortical and pith tissues. Postharvest Biology and Technology. 26: 23–33.

Manning, K. (1996). Soft fruits. In G. B. Seymour, J. E. Taylor, & G. A. Tucker (Eds.), Biochemistry of fruit ripening. Chapman & Hall., London, pp. 347–377.

Montero, T.M., E.M. Molla, R.M. Esteban and F.J. Lo pez-Andreu (1996). Quality attributes of strawberry during ripening. Scientia Horticulturae, 65: 239–250.

Nogata, Y., H. Ohta and A.G.V. Voragen (1993). Polygalacturonase in strawberry fruit. Phytochemistry. 34: 617–620.

Nunes, M.C.M., J.K. Brecht, A.M.M.B. Morais, and S.A. Sargent (1995). Physical and chemical quality characteristics of strawberries after storage are reduced by a short delay to cooling. Postharv. Biol. Technol. 6: 17–28

Olsson, M.E., J. Ekvall, K.E. Gustavsson, J. Nilsson, D. Pillai, I. Sjoholm, U. Svensson, B. Akesson, and M.G.L. Nyman (2004). Antioxidants, low molecular weight carbohydrates, and total antioxidant capacity in strawberries (*Fragaria ananassa*): effects of cultivar, ripening, and storage. J. Agric. Food Chem. 52: 2490–2498.

Reyes, F.G.R., R.E. Wrolstad and C.J. Cornwell (1982). Comparison of enzymic, gas–liquid chromatographic, and high performance liquid chromatographic methods for determining sugars and organic acids in strawberries at three stages of maturity. J. Assoc. Offic. Anal. Chem. 65: 126–131.

Salunkhe, D.K. and B.B. Desai (1984). Strawberries. In: Postharvest Biotechnology of Fruits, Vol. I. CRC Press, Boca Raton.

Shamaila, M., T.E. Baumann, G.W. Eaton, W.D. Powrie and B.J. Skura (1992). Quality attributes of strawberry cultivars grown in British Columbia. J. Food Sci. 57(3): 695-699.

Spayd, S.E. and J.R. Morris (1981). Physical and chemical characteristics of pure from once-over harvested strawberries. J. Am. Soc. Hortic. Sci. 106: 101–105.

Steel, R.G.D., J.H. Torrie and D. Dickey. (1997). Principles and procedures of statistics: a biometrical approach. 3rd Ed McGraw Hill Book Co Inc, New York.

Woodward, J.R. (1972). Physical and chemical changes in developing strawberry fruits. Journal of the Science of Food and Agriculture 23: 465-473.

Youngjae, S., H.L. Rui, F.N. Jacqueline, H. Darryl and Christopher (2007). Temperature and relative humidity effects on quality, total ascorbic acid, phenolics and flavonoid concentrations, and antioxidant activity of strawberry. Technology 45: 349-357.