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Effect of Harvesting Stages and Storage Temperature on Physicochemical Properties and Antioxidant Activities of Yellow Cherry Tomato (Lycopersicon Esculentum Var.Cerasiforme)

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***Abstract*— This present study was conducted to evaluate the effect of harvesting stages and storage temperature on physicochemical properties and antioxidant activities of yellow cherry tomato (*Lycopersicon esculentum var. cerasiforme)* under ambient temperature (29^{o}C±1) and low temperature (9^{o}C±1). Fruit of three maturity stages including green mature (turning), light yellow (half ripen) and yellow (full ripen) were kept under open condition with room temperature (29^{o}C±1, RH 80%±5) and covering with PVC film in low temperature (9^{o}C±1, RH 55%±3). After sixteen days of storage under ambient condition, the green tomato had the highest change of firmness and its total phenolic compounds (PO) and antioxidant activities (AA) were lower than half ripen and ripen tomatoes. There is a little change in color and less decreasing of firmness occurring in yellow tomato after 16 days of storage. In addition, total solube solids (TSS) of yellow tomato was high, but there were strongly decreases in AA and PO than in light yellow tomato after 16 days of storage. The similar trend of changing in physicochemical properties and antioxidant activity occurred in sample stored in cool conditions (9^{o}C), especially TSS, loss weight, PO and AA were more stable than those keeping in high temperarue (29^{o}C). These results conduct that the harvesting stages should be considered to be suitable with storage conditions to prolong yellow cherry tomato after postharvest.**

Keywords*— S*torage, cherry tomato, maturity, Lycopersicon esculentum var. cerasiforme, temperature

INTRODUCTION

Tomato is one of food sources rich in nutrients, widely grown vegetables and easy consumption. The ripen tomato fruit contents vitamin C, B, K, β-caroten, organic acids and mineral such as Mg, Ca, Fe,..[1, 2]. Using fresh tomato and processed tomato in daily meal can reduce risk of cancer and cardiovascular disease [3]. Tomatoes also are powerful in antioxidant capabilities due to the bioactive compounds in fruit [4] such as lycopene, ascorbic acid, tocopherols and phenolic compounds [3-8]. However, tomatoes have a short shelf life because of the ripening process happened quickly. Many factors affect the quality of tomato fruits after harvest such as weather condition during harvest [9], storage temperature , humidity [10] or packaging [11]. Fresh tomatoes that stored around 10°C was more favorable as compared to high temperature (24-30^{o}C) for prolonged shelf life and remain fresh tomato quality [12, 13]. Cherry and grape tomatoes are sometimes held at lower than recommended temperatures.

Around the world, thousands of tomato species having been cultivated, typically tomberries, cherry tomatoes, or beefsteak tomatoes. Most cultivars produce red fruit, but a number of cultivars with yellow, black, orange,.. are also available. Cherry tomatoes are sold at a premium in many wet markets and supermarkets in Vietnam. Both Vietnamese customers and farmers are professional to select quality of red or pink ripen tomatoes, however, the yellow tomato or others newly grown in some areas in Vietnam are not familiar with all of local people. The fruit harvested before reaching maturity requirements lead to physiological disorders during storage and reduces product quality.

In our country, currently the harvesting stage of yellow cherry tomato of most gardeners are arbitrary, depending on market demand and conditions of transportation or preservation. In addition, postharvest products are mainly sold in the wet markets in which tomatoes are stored at ambient temperature (25-35^{o}C). The advantage of this trading is simple, and low storage costs but shelf life of tomatoes commercially short, quality declines rapidly. The method using low temperature to preserve tomatoes in supermarkets can prolong storage time and stabilize their quality [5,14-16]. But with economic conditions and buying habits in our country, they are still widely used in the transportation for tomato in ambient temperature, and mainly sell them at the wet markets. In this study, hence we hope to give the effect of harvesting stages to physicochemical properties (hardness, TSS, color, loss weight), total phenolic content and antioxidant activity of yellow cherry tomatoes when stored at normal temperature (as wet markets) and low temperature (as supermarkets) in order to determine which is the best ripen stage of these tomatoes matching with each preservation method. The findings from the study can be used to improve the shelf life and tomato quality.

MATERIAL AND METHODS

Sample preparation

Yellow cherry tomato, 54kg, were harvested at three maturity stages including green mature (turning), light yellow (half ripen) and yellow (full ripen) from one orchard in Dat Lat and transported to laboratory within 4 hours. Samples were assigned to two experimental conditions. A half of tomatoes were separated in the small baskets (1 kg/basket) and kept at ambient conditions prevailing in the laboratory temperature ($29^oC \pm 1$, humidity 80% ± 2) and the other part was packed in EPS trays covering with PVC film (1 kg/ tray) and stored in a refrigerator maintained at cold temperature (9°C ± 1, humidity 55% ± 3).

Physicochemical properties (firmness, color, weight loss, total soluble solids content), polyphenol and antioxidant properties were recorded on 0, 4, 8, 12 16 days of storage.

Reagents: 1,1-diphenyl-2-picrylhydrazyl, gallic acid were perchased from Sigma Aldrich Chemical Co.(America), Folin-Ciocalteu, Trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid) were bought from Merck (Germany). Methanol and other chemicals at analysis standards were perchased mb from Vietnam.

Analytical procedure

Weight loss (%): The weight loss of tomato fruit sample was calculated by using the following formula:

% Total weight loss = (Initial weight - Final weight) x100/ Initial weight

Color: Tomato fruit surface color was measured with a hunterlab (MiniScan XE Plus, Hunter Associates Laboratory, Inc., Reston, Virginia, USA). The difference in color is show by ΔE:

$$\Delta E = \sqrt{(L_2 - L_1)^2 + (a_2 - a_1)^2 + (b_2 - b_1)^2}$$

Firmness of tissue: Firmness was determined by using a Rheometer (Sun Scientific, Co., Japan) according to method of M. Joseph Ahrens [17]. The results were expressed by N/cm^2

Total soluble solids: Total soluble solids were determined using hand refractometer (Atago, Japan) and values were expressed as °Brix.

Total phenolic contents (PO): Total phenolic content was determined by using the Folin-Ciocalteau phenol reagent method of Singleton and Rossi, 1965 [18]. Briefly, 100 µl of each tomato methanolic extract was mixed thoroughly with 5 ml of distilled water and 1 ml of FolinCiocalteau reagent. The mixture was then kept for 5 min and 2 ml of 20% w/v sodium carbonate solution was added and the volume was made up to 10 ml with distilled water. The same procedure was also done to the standard solutions of gallic acid. The absorbance at 765 nm of each mixture was measured on a UV-Vis Carry 50 spectrophotometer (Varian Co., USA) after incubation for 30 min at 30°C. Concentration of PO was expressed as mg gallic acid equivalent (GAE) in 100g fresh weight of tomato fruit (mgGAE/100g).

Antioxidant activity: Antioxidant activity of tomato was determined by using free radical, DPPH (2,2-diphenyl-1-picrylhydrazyl) according to procedure of Brand-Williams, 1995 [19] with some modifications. Briefly, 0.5 mL of methanolic tomato extract and 2.5 mL of freshly prepared $0.1 mmol L^{-1}$ DPPH methanolic solutions were thoroughly mixed and kept for 30 min in the dark. The absorbance of the reaction mixture at 517 nm was read with a spectro-photometer. Trolox (6-hydroxy-2,5,7,8-tetramethyl-chroman-2-carboxylic acid) was used as a standard. The results were shown by µmol Trolox per 100 g fresh weight (µmol Trolox/100g).

Statistical Analysis

All analysis was performed in triplicate and data were expressed as mean ± standard deviation. Statistical analysis was performed using Statistica 8.0. The data were analyzed by using variance analysis (ANOVA) and statistical differences with p-values under 0.05 were considered significant. Tukey's test was performed to analyze differences among means by software and the graphs were decribed by using Microsoft Excel 2010.

RESULTS AND DISCUSSION

Harvesting stages and storage temperature play important roles in quality maintenance by slowing down the changes of physical properties and antioxidant activity thus increasing the shelf life of fresh produce [9]. The effect of temperature shelf life of tomato is well established. The low temperature have shown positive results in the quality retention of fruits through maintenance of firmness and reducing the respiration rates. Influence of maturity stages of popular tomato cultivars were studied [22,31,32]. The experiment was consisted of three ripen stages of yellow cherry tomato fruit in high temperature ($29^oC \pm 1$) and in low temperature ($9^oC \pm 1$). The results obtained from the investigation are presented in the following:

Weight loss (%): The results of weight loss of tomato samples stored at room temperature and cool temperature are shown in Figure 1a &1b. Natural weight loss of tomato increased with storage time of three ripen stages in the both low and high temperature condition. There was no significant difference ($P>0.05$) in weight loss of three samples storage at room temperature. This finding coincides with the results of KM Moneruzzaman et al (2009). However, the full ripen tomatoes were faster loss weight than haft ripen and green tomatoes when storing at 9^oC. The decrease of total weight loss in ripen tomatoes during storage time due to higher in the respiratory rate which leading to loss of dry matter and water content faster. The use of plastic bags for packaging fruit limiting evaporation to slow evaporation and dehydration [20], so the weight loss is low compared with stored at room temperature without packaging.

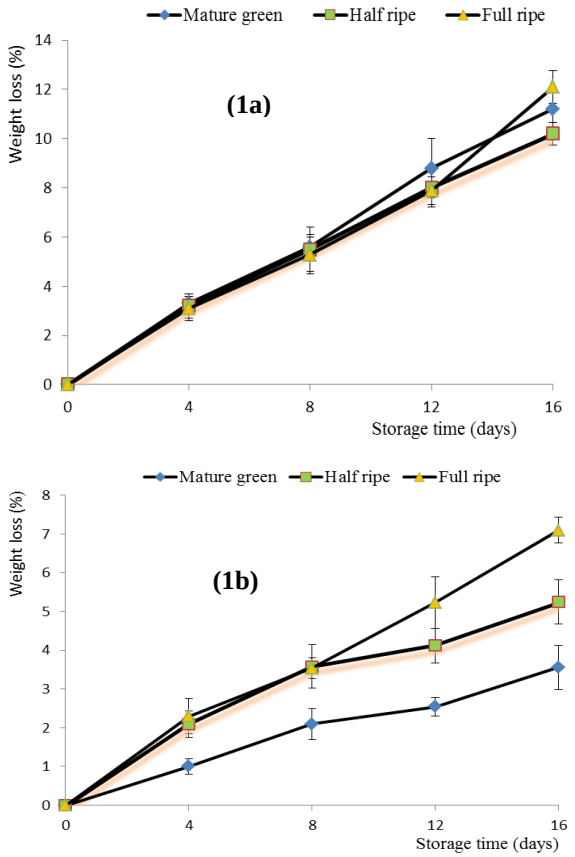

Fig. 1. Changes in weight loss of tomatoes during 16 days of storage under different temperature, 9°C (1a) and 29°C (1b)

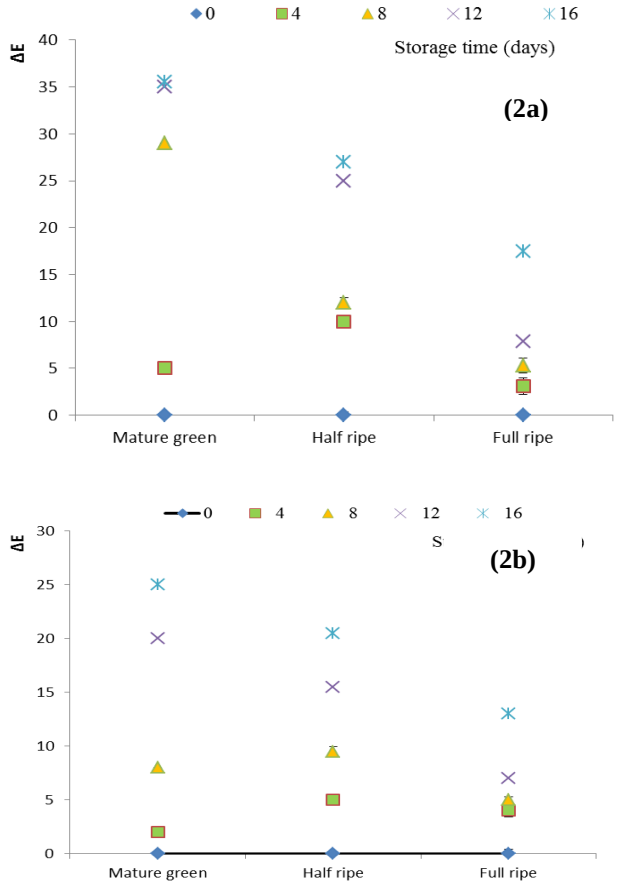

Fig. 2. Changes in color of tomatoes during 16 days of storage under different temperature, 9°C (2a) and 29°C (2b)

Color: The changes in color of the tomatoes during storage time are due to the ripening process, chlorophyl is hydrolyzed by the enzyme leading green color is reduced and ripen color is developed. The carotenoids pigments, for example, are synthesized to create color characterizes of ripe fruit [21]. In this research, the ΔE values of turning and haft ripe tomatoes were higher than in full ripe tomatoes (Fig. 2a&b). Comparision of two different temperature storage, the ΔE value of samples stored at 9°C (Fig. 2a) were almost lower than samples stored at 29°C (Fig. 2b). The changing trend in color of full ripe in two storage conditions were almost the same, ΔE around 15 in both 9°C and 29°C storage). This trend was similar occurring in half ripen tomato, ΔE around 25 in both 9°C and 29°C storage). Whereas, the ΔE value of green tomatoes stored at 9°C was lower light yellow tomato but this value was highest when stored ambient condition. The color changes in fruit are proportional to the intensity of its respiration. The samples in cryopreservation are slower respiration rate thus less color change.

Firmness: The results of changes in the firmness of tomatoes stored at room temperature and low temperature are shown in Fig.3a&b. Firmness of tomato depends on ripening stages. The firmness of the three ripen stages of tomato pulp stored at ambient condition and refrigeration were reduced ($P<0.05$). The most reduce of firmness occurred in green tomato in both storage conditions, droping from 300 (N/cm^2) to 141 (N/cm^2) after 16days of storage at 29°C. Meanwhile, samples stored at low temperatures, the hardness was relatively stable, and only green tomato significantly reduced ($P<0.05$) after 12 days of storage. Firmness of tomatoes reduces due to the activity of the enzyme by resolution glucide substances in fruit; hemicenllulose hydrolyzed into pentose and cenllulose; protopectin hydrolyzed into soluble pectin, leading to fruit softening gradually. Low temperature condition will inhibit the physiological processes occur in biochemical tissue to slow down the ripening process [20,22], as a result the consistency of the fruit is maintained during storage [23]. According to research by De Castro LR et al, 2006 [5] showed that green tomatoes stored at higher temperatures were sweetness than samples stored at low temperatures, however, less stiffness associated with a decrease in weight loss.

Total soluble solids: TSS content is an index used to measure the total dissolved solids (including sugar, acids, in vitamin, soluble pectin) in the fruit, it reflects the level of maturity of fruits. During storage time, TSS were increased in all three maturity (Fig. 3a & b). This result is similar with research of Shehla et al, 2007 [32] and Abdullah et al, 2004 [1], the total soluble solids of tomato increased during storage if harvested

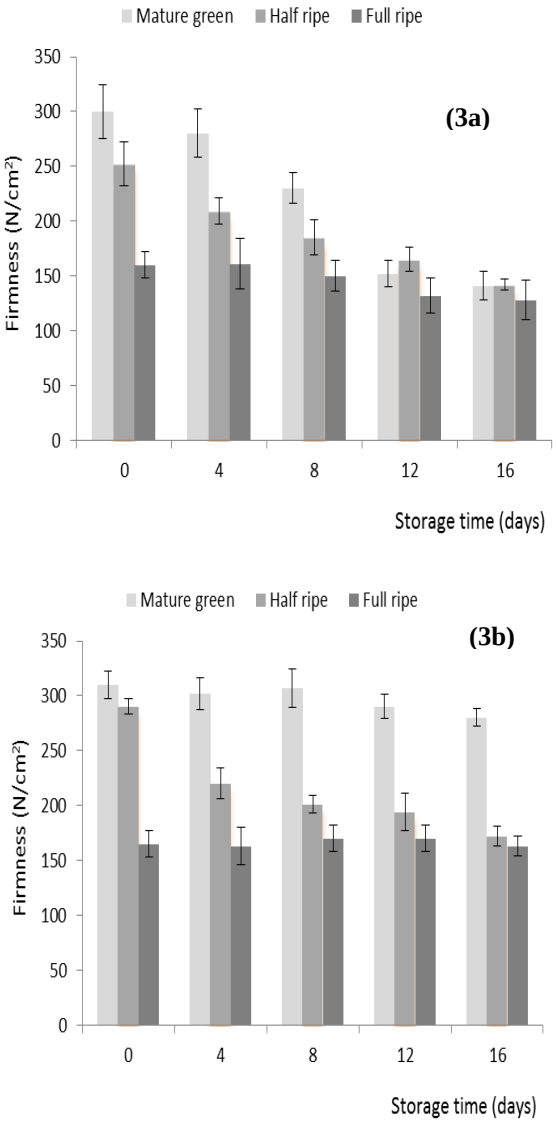

Fig. 3. Changes in firmness of tomatoes during 16 days of storage under different temperature, 9°C (3a) and 29°C (3b)

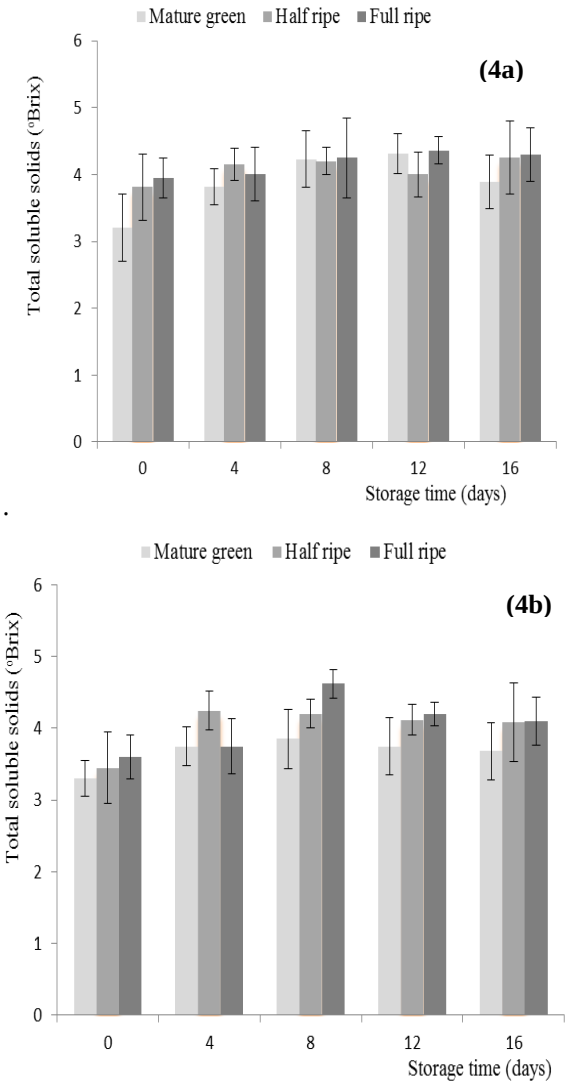

Fig. 4. Changes in TSS of tomatoes during 16 days of storage under different temperature, 9°C (4a) and 29°C (4b)

at different maturity level, kept at a different temperature degrees and used different packaging methods.

Antioxidant activities: Tomatoes are one of the fruits has been evaluated as having high antioxidant activity [8, 26-28] because of its fruit contains compounds with biological activity such as lycopene, ascorbic acid and a variety of other phenolic compounds [11]. It is well know that the phenolic compounds have a protective effect on the stability of some vitamins such as vitamin C, E. The results of PO of three kind of tomatoes stored at normal temperature and low temperature are shown in Fig. 5a&b. The PO decreased during storage time. Of the three kind of tomatoes, PO of half ripen tomato one was the highest, 42.5 (mgGAE /100g); full ripe was 37.2 (mgGAE/100g) and green tomatoes was 28.5 (mgGAE/100g).

After 16 days of storage, the PO of samples stored in 29°C were significant decrease comparing samples stored in 9°C.There was only the sample stored at room temperature after the 4 day storage PO content slightly increased, from 42.5 (mgGAE/100g) to 43.5 (mgGAE/100g). The increased levels of polyphenols in the preservation process remains controversial. Hunt, 1980 [7] and Smith, 1973 [29] suggests that the increase enzyme activity could promote the synthesis of polyphenol base on phenylalanine ammonialyase enzyme.

Research aslo showed that AA varies by maturity and reached the highest value in full ripen tomato, 140.1 (µmol trolox/100g), the lower values obtaining in half ripe and green tomato were 135.1 and 70.3 (µmol trolox/100g) respectively (Fig. 6a&b). This result is the same tendency with some previous studies [27, 32]. Observations at the same time of storage, AA of samples storing high temperature strongly reduced than those stored at low temperature.

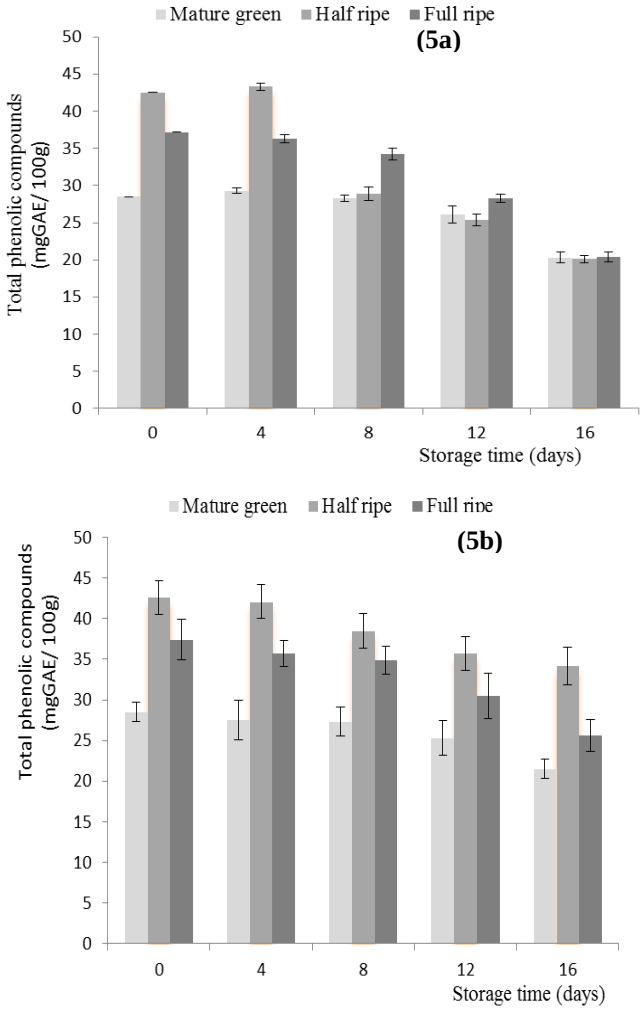

Fig. 5. Changes in PO of tomatoes during 16 days of storage under different temperature, 9°C (5a) and 29°C (5b)

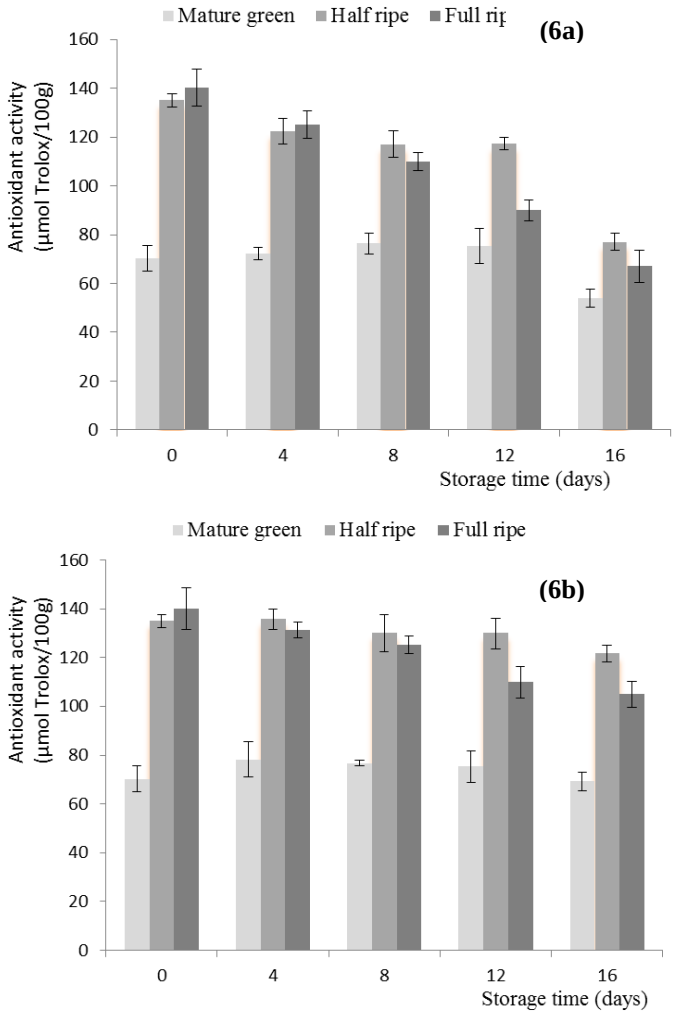

Fig. 6. Changes in AA of tomatoes during 16 days of storage under different temperature, 9°C (6a) and 29°C (6b)

Antioxidant activity reflects the amount of lycopene, ascorbic acid and phenolic compounds. Research by Dumas et al, 2003 [30] and Toor & Savage, 2006 [31] indicates that the antioxidant activity of hydrophilic compounds accounted for 92% and only 8% of this activity from preferred lipophilic substances

CONCLUSION

Harvesting stages and storage temperature affect physicochemical properties (weight loss, TSS, hardness, color) and antioxidant activity, polyphenol content of selected samples. Yellow cherry tomatoes stored at low temperatures had maintained color, firmness, weight loss, AA, PO than those storage ambient condition. In three types of tomatoes, light yellow tomatoes after 16 days storage time reamained highest AA and PO content compare to others in both temperature conditions. Besides, color and TSS of this tomato were aslo stable. From these results allowing conclusion that the half ripe of yellow cherry tomatoes consist with cryopreservation can maintain better quality after postharvest for yellow cherry tomatoes.

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