

**COMPARISON OF PHYSIOCHEMICAL CHANGES IN TWO POPULAR
STRAWBERRY CULTIVARS GROWN IN IRAN (cvs. KURDISTAN &
SELVA) DURING STORAGE TIME AT 4 °C**

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Jouki M., and A. Dadashpour (2012): *Comparison of physiochemical changes in two popular strawberry cultivars grown in iran (cvs. Kurdistan & Selva) during storage time at 4 °C.* - Genetika, Vol 44, No. 3, 679-688.

In this study the effect of storage time on some quality parameters of two strawberry cultivars fruits storage at 4°C have been evaluated. Several quality parameters were monitored during the storage period. The samples were analyzed 1, 7, 14 and 21days during storage. Fruits were analyzed about fruit weight, sugar content, chromatic parameters L*, a*, b*, fruit firmness, total titrable acidity, pH, and sensory evaluation. The Kurdistan strawberries retained their weight throughout the experiment as opposed to the Selva strawberries which lost 0.6% of their weight per day because of dehydration. The Selva cultivar was exceptionally firmer than Kurdistan strawberries. Two cultivars were rich in vitamin C and sugar but these values were more in Kurdistan cultivar. As expected, Chroma

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decreased and over the storage time in two cultivars. The results of this study showed that packaged Kurdistan strawberries could prove suitable for 7 days at 4°C compare with 4 days for selva strawberries.

Key words: firmness, quality parameters, strawberry

INTRODUCTION

Strawberry is an important small fruit, grown throughout the world. More than 50,000 tons of strawberries are produced in Iran each year. Kurdistan is located in the north west of Iran. With more than 40,000 tons production per year, Kurdistan is the largest area of the strawberry production in Iran (HARIGI & GHADERI, 2007). Strawberries are a good source of ascorbic acid (vitamin C) which is a very important nutrient, being essential, e.g. for the synthesis of collagen (CASTRO *et al.*, 2004). Strawberries have short shelf life due to highly perishability and are susceptible to mechanical injury, physiological disorders, water loss, and decay (CANER *et al.*, 2008). The shelf-life of fresh fruit is limited to 1~2 days at room temperature (HARKER *et al.*, 2000). The main cultivar under cultivation in Iran is 'Kurdistan'. This is a short day cultivar (USDA, 2004). Demand for this cultivar is very big because of their aroma and flavor (MORGAN, 2006). Consequently, the most commonly used method for shelf-life extension is low temperature. But storage quality can be further improved by altering the gas atmosphere surrounding the fresh strawberry (HOLCROFT & KADER, 1999). Some researchers have been done on physic-chemical characteristics of bitter orange (KHAZAEI *et al.*, 2012; KHAZAEI *et al.*, 2011), pear (DADASHPOUR *et al.*, 2012) and nectarine (JOUKI & KHAZAEI, 2011) during storage time and on strawberry (JOUKI & KHAZAEI, 2012) under modified atmosphere packaging. There are many hundreds of strawberry cultivars in commercial production around the world with new varieties being continually bred. Greenhouse strawberry growers should trial a number of local and commercially grown varieties within their production system (NUNES *et al.*, 2006). This comparative study was conducted to investigate the changes of physicochemical parameters of two popular cultivars strawberries during storage at 4°C.

MATERIALS AND METHODS

Sample collection and preparation

Strawberries grown in Sanandaj area in Kurdistan, Iran (cultivars Kurdistan and Selva) were harvested from strawberry bushes in the morning in September 2010. After harvesting, sorting (medium size and ripe strawberries) and cutting their stems, they were transported in air-conditioned vans to the Laboratory of packaging and Post-Harvest Physiology of Fruits at the University of Tehran. Polyethylene (PE) packaging rolls were used for preparation of packages of 30 cm ×20 cm. The analyses were made at 1th, 7th, 14th and 21th days.

Firmness

Fruit flesh firmness was assessed using a texture analyzer. Speed of 20 mm/s and penetration distance of 6 mm was used to cut the segments at the center, and the firmness was expressed as maximum cutting force (N). The segments similar in thickness were selected for firmness measurement. Six segments from two parallel packages (10 segments/ package) were measured for each treatment on each sampling day (TAS, 2007). The readings were recorded in N force. The storage duration was determined for each treatment.

Weight loss

Weight loss was calculated by the following equation:

$$\text{Weight loss (g/100 g)} = (W_0 - W_d) / W_0 \times 100$$

Where W_0 is first day weight and W_d is desired day after storage (KIM *et al.*, 2006).

pH

The pH of the strawberry homogenate was analyzed by a pH meter (Metrohm, Herisau, Switzerland) in duplicate measurements on day 1, 7, 14 and 21.

Acidity

Each sample (25g) was blended for 3 min. and filtered by using cheese cloth. The prepared juice of the sample was used for chemical analysis. The acidity was measured by titration with 0.1 N NaOH (AOAC, 1997). Results were expressed as percent citric acid.

Sugar contents

Sugar contents were determined based on the Gravimeter-Fehling method (NIGAM & AYYAGARI, 2008).

Colour

The homogenate was poured into petri dishes and the colour was measured using a colour meter (Minolta Spectramatch, Tokyo, Japan). Triplicate samples were analyzed and three measurements were made on each sample. Analyses were performed day 0, 7, 14 and 21. Three measurements were taken at random locations and the CIELAB L^* , a^* , b^* parameters were recorded. Total colour change (ΔE), chroma (C) and hue angle (h) were calculated using equations described by MASKAN (2001):

$$\Delta E = ((L_0 - L)^2 + (a_0 - a)^2 + (b_0 - b)^2)^{1/2} \quad (1)$$

$$C^* = (a^{*2} + b^{*2})^{1/2} \quad (2)$$

$$\text{Hue angle} = \tan^{-1} b^*/a^* \quad (3)$$

Fungal decay

The presence of *Botrytis cinerea* was estimated visually in each individual fruit immediately after opening the packages. Wild strawberry fruits showing surface mycelial development were considered decayed. Results were expressed as % of fruits infected by *Botrytis*.

Sensory evaluation

Packaged samples with different atmospheres were evaluated for overall appearance, firmness, aroma and acidity using a 5-point rating scale with six trained panelists. The attributes and product acceptability were expressed as follows: Visual appearance include 5: excellent/fresh; 4: good; 3: acceptable; 2: poor; 1: very poor. Aroma include 5: natural; 4: loss of aroma; 3: no aroma; 2: light strange aroma; 1: strong strange aroma. Firmness include 5: excellent firmness/juiciness; 4: firm/juicy; 3: acceptable firmness/juiciness; 2: hard; 1: very hard. Acidity include 5: very good; 4: good; 3: acceptable; 2: acidic; 1: too much acidity (KARACAY & AYHAN, 2009).

Statistical analysis

Statistical analysis was carried out using the General Linear Models Procedure of SAS. Duncan's multiple range test was used for multiple comparison and separation of means.

RESULTS AND DISCUSSION

Weight loss %

One of the characteristics of strawberry fruits that contribute to their highly perishable character is rapid loss of water (OZKAYA *et al.*, 2009). Part of respiration and transpiration of a fresh product can be expressed by the change of its weight loss (ZHANG *et al.*, 2001). Weight loss was significantly affected by storage time ($P < 0.01$). The amount of weight loss increased during the storage period resulted in increase in weight loss (Fig. 1). In this study, significant differences ($P < 0.05$) in weight loss were found for the different packages. After 7 days at 4°C the highest weight losses (2.9%) were obtained for Selva strawberries. At the end of the storage period, Selva strawberries lost 8.48% weight, and the amount of weight loss in the Kurdistan strawberries was exceptionally less than Selva strawberries.

Sugar

The initial sugar concentrations were 10.5% in Kurdistan strawberries and this value was 10.1 in Selva cultivar. During storage the sugar levels in two cultivars dropped slightly. This can be explained by sugars being consumed through respiration. During storage, the sugar concentration tended to increase in two cultivars but this increase was not statistically significant. The minor rise in sugar concentration in the samples is probably due to water loss that is the total amount of

sugars did not increase but sugars made up a larger percentage of the weight as the dehydrated strawberries.

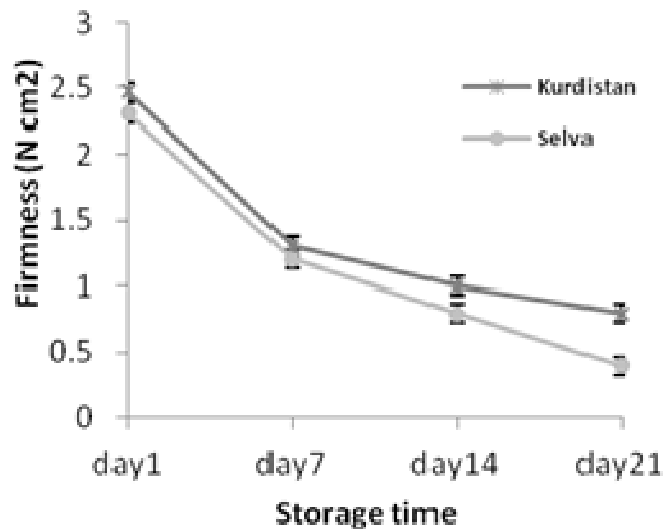


Figure 1. Losses of weight in strawberries during storage at 4°C.

pH and Total Titrable Acidity

The pH value of Selva and Kurdistan cultivars were 3.55 ± 0.32 and 3.60 ± 0.27 at first day of storage time. During the storage period, a reduction was observed on fruits' pH between the first and the fourteenth day, following an increase of the same, but did not suffer a statistically significant variation. PH decreased in Kurdistan and Selva cultivars from 3.6 to 3.52 and from 3.55 to 3.53, respectively in the end of storage time. The ATT showed an increase at the beginning of the storage (up to the fourteenth day) and then there was a reduction between the fourteenth and twenty-first days. The reduction of ATT in strawberries beginning at the 14th day of its storage must have been a result of acid oxidation during the Krebs cycle, once that this constitutes an excellent energy reserve for the fruit. However, our results regarding to pH and titrable acidity are not in agreement with those obtained by OZKAYA *et al* (2009) and ALMENAR *et al* (2007) who reported the increase in acidity of strawberries during storage. An explanation of this is that they use other varieties.

Fungal decay

No mould growth was detected after 7 days of storage in Kurdistan strawberries but this time was 4 days for Selva Strawberries. In this study the presence of *B. cinerea* was observed in two cultivars at the end of storage (85-100%) (Fig. 2). Packaged Kurdistan strawberries could prove suitable for 1 week at 4°C.

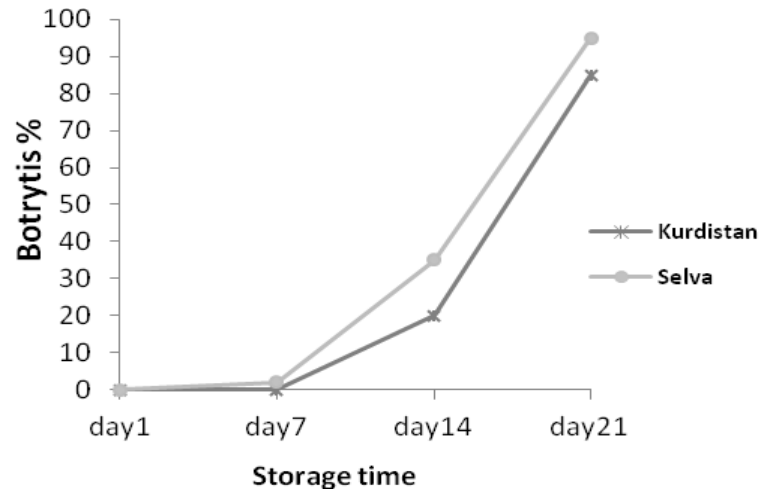


Figure 2. Development of *Botrytis* fruit rot in Kurdistan strawberry fruits during storage time at 4°C.

Firmness

All the samples were tested after storage interval of one week. The firmness was decreased after each storage interval. Firmness decreased by 77% in Kurdistan strawberries and 83% in Selva cultivar (Fig. 3). It is known that the mechanical properties of fruits depend on cell wall strength, cell-to-cell adhesion, cell packing and the internal pressure or turgor of cells (NUNES *et al.*, 2005). The Selva cultivar was exceptionally firmer than Kurdistan strawberries at the end of the storage time.

Color

Color of strawberry is one of the most important quality factors of fresh strawberry for consumer preference. The color development rate of strawberry increased with increasing maturation. Color was measured by Colorimeter and Color Difference on color coordinates L*, a*, b* values, where L-value is lightness, a-value is redness-greenness, and b-value is blueness-yellowness. L values decreased at the beginning and became stable at the end of storage. During storage, the L*

value tended to decrease in both Kurdiatan and Selva cultivars. At the end of the storage time the L^* in the Kurdistan strawberries was higher than the Selva cultivar. As in the present study, decrease in the L^* value of strawberry fruit have previously been reported by others researches (ALMENAR *et al.*, 2007; HARKER *et al.*, 1997). The a^* value increased significantly during 7 days of storage, which is probably supported by the accumulation of anthocyanin pigments and high degree of red fruit. On the other hand b-values decreased in the first two weeks and then became stable. The chroma value describes its brightness while the hue angle represents a coordinate in a standardized color space. The results are presented in Table 1. As expected, Chroma decreased and over the storage time in two cultivars. Strawberries became more red (lower hue angle) during the storage period.

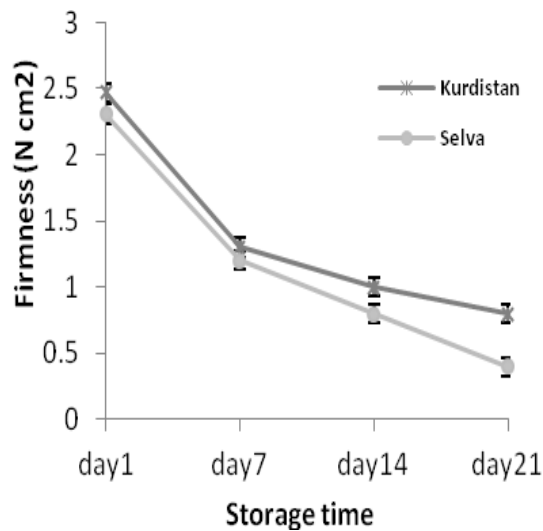


Figure 3. Evaluation of firmness of strawberries during storage time at 4°C.

Sensory quality of bitter orange segments

The sensory analyses were performed to establish any sensorial differences between the different packaging conditions after 7, 14 and 21 days of storage of the strawberries. Four attributes (Table 2) were judged by the assessors. The results of the sensory evaluation are presented in Table 2. These observations were well in accordance with the findings from the aroma analyses. Packaged Kurdistan strawberries under air were found acceptable for 7 days in terms of sensory quality.

Table 1. Colour changes of strawberries stored for 21 days at 4 °C.

Treatments	time	L*	a*	b*	Hue	Chroma
Kurdistan	Day 0	35.96±3.12	30.11±3.00	21.50±3.90	35.54	36.99
	Day 7	33.55±3.61	31.16±3.12	20.54±4.11	32.10	36.77
	Day 14	29.70±4.23	31.51±3.87	18.25±3.66	30.09	36.41
	Day 21	—	—	—	—	—
Selva	Day 0	33.83±2.65	28.13±2.43	22.18±2.13	37.90	35.82
	Day 7	32.17±2.90	28.59±3.52	20.60±3.70	35.79	35.23
	Day 14	26.12±3.51	29.89±2.28	19.12±2.66	32.61	35.48
	Day 21	—	—	—	—	—

Table 2. Sensory attributes of strawberries during storage at 4°C.

Treatments	time	Visual appearance	firmness	aroma	acidity
Kurdistan	Day 0	4.6 ± 0.44	4.4± 0.33	4.6± 0.87	4.2± 0.67
	Day 7	3.9 ± 1.37	3.8± 0.43	3.9± 0.22	3.8± 0.65
	Day 14	2.6 ± 0.65	3.1± 0.26	2.6± 0.66	-
	Day 21	1.5 ± 0.81	1.2± 0.24	2.4± 0.87	-
Selva	Day 0	4.7 ± 0.73	4.2 ± 0.13	4.6 ± 0.51	4.5 ± 0.34
	Day 7	3.4 ± 1.24	3.1 ± 1.68	3.7 ± 1.22	-
	Day 14	2.4 ± 0.49	1.9 ± 0.39	2.3 ± 0.78	-
	Day 21	1.2 ± 0.87	1 ± 0.91	1.5 ± 0.59	-

Mean values followed by the different letter for a given parameter are significantly different ($P = 0.05$)

ACKNOWLEDGEMENTS

This study was partly supported by Young Researchers Club- Islamic Azad University- Shahr-e-qods branch, I. R. Iran.

Received June 30th, 2012

Accepted December 04th, 2012

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**UPOREDNO ISPITIVANJE FIZIOLOŠKO HEMIJSKIH PROMENA
U DVE SORT JAGODE GAJENE U IRANU (cvs. KURDISTAN & SELVA) U
TOKU SKLADIŠTENJA NA 4⁰ C**

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Vršena su ispitivanja efekta vremena skladištenja na neke parameter kvaliteta dve sorte jagode na 4⁰ C. Nekoliko parametara kvaliteta je ispitivano uzimanjem uzoraka 1, 7, 14 i 21 dan skladištenja. Vršene su analize težine ploda, sadržaja šećera, parametric boje L*, a*, b*, čvrstina ploda totalna kiselost dobijena titriranjem, pH i ecenjivanje osetljivosti. Plodovi sorte Kurdistan su zadržali početnu težinu, za razliku od sorte Selva, čiji plodovi su gubili 0.6% tržine dnevno zbog dehidracije. Plodovi sorte Selva su zadržali čvrstinu u odnosu na plodove sorte Kurdistan. Kao što je očekivano boja je bleдела kod plodova obe sorte u toku skladištenja. Dobijeni rezultati su pokazali da se pakovanje plodova sorte Kurdistan ostaju dobrog kvaliteta sedam dana u toku skladištenja na 4⁰ C za razliku od plodova sorte Selva koji zadržavaju kvalitet u toku četiri dana skladištenja.

Primljeno 30. VI. 2012.

Odobreno 04. XII. 2012.