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EFFECT OF LOW TEMPERATURES ON PHYSICO-CHEMICAL PROPERTIES OF DIFFERENT STRAWBERRY CULTIVARS

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ABSTRACT

Texture, anthocyanin content, pH, acidity, totals soluble solids, total sugar, and sensory scores of five strawberry cultivars (Kurdistan, Selva, Camarosa, Paroz, and Queen), stored at 6 ºC, was investigated. The data indicated physical and chemical properties of all samples depended on cultivate during storage time since there were some contrasting responses among cultivars. 'Kurdistan' had the highest moisture content and showed decay symptoms previously. Except for 'Camarosa', TSS and total sugar increased in all cultivars. There were differences between cultivars concerning changes of acidity or pH over the storage period. In terms of flavor, 'Kurdistan', 'Camarosa', and 'Selva' cultivars were found better than the others at first day of cool storage. But 'Camarosa' and 'Selva' had a favorite color among cultivars. A sign of fungal decay was observed in 'Kurdistan' samples at 7th day.

Keywords: strawberry, physico-chemical properties, cool storage, sensory score.

INTRODUCTION

Strawberry is a non-climacteric fruit with limited shelf life due to its high sensitivity to chemical and microbial deterioration during postharvest storage and handling. It must be harvested at full maturity to achieve the maximum quality in relation to flavor and color. The main changes in fruit composition which are usually associated with ripening, take place when the fruit is still attached to the mother plant. As a consequence, strawberries should be harvested ready for consumption. This means there is a very short period of fruit at its best quality. In order to slow down metabolism and reduce deterioration prior to transport or storage, strawberries must be cooled to low temperatures after harvest. The postharvest life of strawberries can be extended by several techniques combined with refrigeration. Low temperatures and modified atmospheres are the tools for avoiding, at least partially, mold growth and fruit senescence, and thus extending the shelf-life of strawberries (Manning, 1996).

In spite of the wide use of low temperatures in strawberry preservation, not much is known about the effects of cool storage on chemical composition, in particular compounds with nutritional value. When strawberry fruits are stored at low temperature, their shelf-life can be extended to at least one week. Nevertheless, the delay between harvest and stored at the proper temperature is critical for the success of the treatment. It was observed that fruits stored at low temperature, 6 h after harvest, showed undesirable changes in color and texture and also a reduction of around 50% of water content in comparison to those that were immediately cooled after harvest (Nunes *et al*., 1995). The main characteristics related to the quality of ripe strawberry fruit are texture, flavor (soluble sugars and organic acids) and color (anthocyanin content). Change in texture is a consequence of the natural process of senescence and also of the atmosphere in which the fruit is stored. Besides the obvious changes in appearance, mold contamination can also promote undesirable changes in texture and contribute to reduced strawberry shelf-life.

Iran has produced 38500 tonnes of strawberry in 2007 (FAO, 2009). Kurdistan province grows about 80% of the total strawberry production in the Iran. In Kurdistan, the predominant cultivar used in planting and processing is 'Kurdistan'. The overall production in Kurdistan accounts for 30,000 tonnes. Processed strawberries account for about 4.5 tonnes in Kurdistan.

The strawberry harvest begins in Kurdistan in May and peaks between May and June and continues until July. The objective of this work was to study texture, chemical composition and sensory score of five strawberry cultivars during one week of cool storage. The temperature of 6ºC was used because it is the average temperature usually applied to keep the fruit, when available for the final consumers.

MATERIAL AND METHODS

Origin and treatment of the strawberries

The study was carried out on strawberry cultivars of Kurdistan, Camarosa, Selva, Queen and Paroz obtained directly from "Agricultural and Natural Resources Research Center of Kurdistan" on the same day. They were transported to a lab in transparent polystyrene containers with a capacity of 500 g and stored at 6ºC. The fruits were carefully selected to be uniform in appearance and free from physical damage and deterioration.

Quality parameters

Firmness of strawberry was determined with a penetrometer for fruit firmness testing (The Wagner FT 02 Penetrometer - Italy). The maximum force to penetrate the fruit sample was recorded as firmness. Each result was the mean of 10 determinations and was expressed in Newton (N).

After firmness analysis, strawberries were cut into small pieces and homogenized in a grinder. Total soluble solids percent (% TSS) was measured in the juice of ground strawberries using an Atago RX-2500 digital

refractometer (Atago Co. Ltd., Tokyo, Japan) at 20°C. A drop of the juice was placed on the lens and the reading was taken in degree Brix. Calibration was made with deionized water and the lens was carefully rinsed between samples.

The pH was recorded by pH meter (pH-526; WTW Measurement Systems, Wissenschaftlich-Technische Werkstätten GmbH, Wellhelm, Germany). In the case of titratable acidity, six grams of ground strawberry was suspended in 20 mL of distilled water and then filtered. The filtrate titrated against 0.1 N NaOH up to pH 8.1 and expressed as citric acid. Total sugar as total reducing sugar was determined according to Iran's Standard (ISIRI, 2007).

Anthocyanin content of strawberries was determined using a spectrophotometric method. 2 g of ground strawberry sample mixed with 20 ml of acidified methanol (1% HCl) using a homogenized and then centrifuged at 2000 g for 15 min. Anthocyanin content was estimated as pelargonidin 3-glucoside at 510 nm, using a molar absorptivity of 36000 $L.cm^{-1}.mol^{-1}$.

Sensory scores of strawberry samples was evaluated by ten trained staff members of the Kurdistan General Department of Standards and Industrial Research. The panelists were asked to evaluate the flavor. A twenty point scale was used where 20 = excellent and 1 = extremely poor. Accuracy and precision were statistically analyzed.

Data analysis

The results were analyzed using one-way analyses of variance (ANOVA) with the statistical software of SPSS (SPSS Inc., Chicago, IL, USA). Differences between means were studied with Duncan's test and differences at $p < 0.05$ were considered to be significant.

RESULTS AND DISCUSSIONS

Anthocyanin

The profile of anthocyanin contents during the storage period is shown in Figure-1. It implies that based on initial amount of anthocyanin, cultivars can be classified as three groups: cultivars with high level of anthocyanin (Camarosa and Selva), medium level of anthocyanin (Kurdistan) and low level of anthocyanin (Queen and Paroz). The initial content of anthocyanin was as high as 41.95 mg/100 g in Camarosa and a little smaller in Selva, while the content of this pigment was significantly lower (below 15 mg/100g) in Queen and Paroz. At the end of studied storage time (7 days), anthocyanin content of Kurdistan and Paroz was not significantly different (p>0.05)
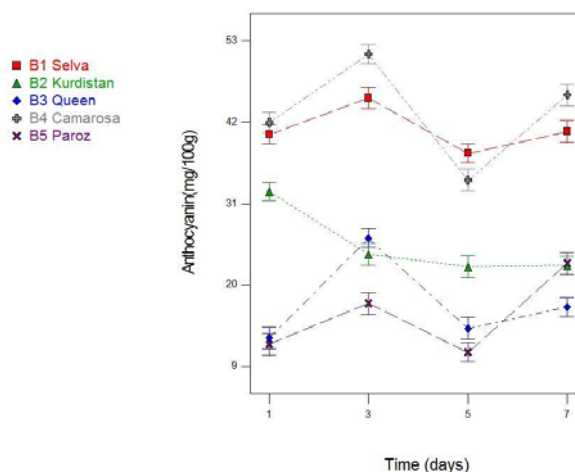
Figure-1. Effect of cool storage at 6°C on anthocyanin content (mg/100g) of five strawberry cultivars.

Figure-1 also shows that profile of anthocyanin change with storage time was similar among four cultivars (Camarosa, Selva, Queen and Paroz) but profile of Kurdistan was different from other cultivars. Fluctuations in anthocyanin content can be originated from different compositions of anthocyanins and chemical changes of them followed by changes in their maximum absorption wavelength.

A total of eight pelargonidin- and three cyanidin-based anthocyanins were found in 39 strawberry cultivars (Baker *et al.*, 1994). Pelargonidin-3-glucoside was the most prevalent pigment, ranging from 100% to 82%. Strawberry pigments are very unstable due to the following chemical changes: hydrolysis of unstable aglycones, degradation of intermediaries, formation of copigment complexes with flavonoids, and degradation due to polyphenoloxidase. These reactions can lead to degrade or cause bathochromic shifts in anthocyanin color (Wesche-Ebeling and Montgomery, 1990; Markakis, 1982; Perera and Baldwin, 2001).
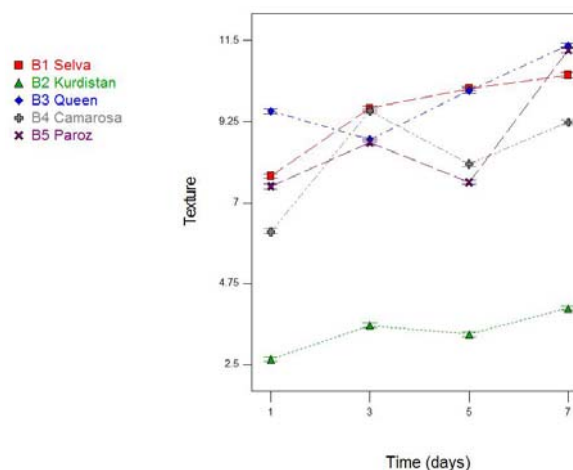
Texture

One of the main factors in determining postharvest fruit deterioration is expressive softening, which reduces shelf life, facilitates pathogen infection and limits transportation and storage. Strawberries show a continuous decrease of cell wall content during ripening (Perkins-Veazie, 1995; Rosli *et al.*, 2004). Moreover, there are multiple chemical changes that involve pectins and the cellulose-xyloglucan framework resulting in solubilization of polyuronides and hemicelluloses (Knee *et al.*, 1977) and loss of neutral sugars (Nogata *et al.*, 1996; Rosli *et al.*, 2004). Huber (1984) stated that strawberry softening may be caused by the action of several enzymes, and may be accompanied by a loss of calcium.

Changes in firmness value between different cultivars during 7 days of storage at 6°C are shown in Figure-2. The values of texture, measured on the first day of cold storage, ranged from 2.63 N for Kurdistan to more

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than 9.54 N for the Queen. Along with difference in initial values of the texture, the trend of textural change with time was also different among cultivars. The firmness of all cultivars at the end of storage time was significantly higher than the first day ($\alpha = 0.05$). Texture changes were more evident in Camarosa, Selva, Queen, and Paroz. Kurdistan cultivar had high moisture and fewer firms than the other cultivars. Soft texture would shorten the shelf-life of strawberry since it would become prone to mechanical injury and to mold contamination. The better characteristic texture of the Camarosa, Selva, Queen and Paroz makes them the most suitable for cool storage. These cultivars would also be an interesting choice when handling the fruit, since they are more resistant to physical injury and abrasion.

Figure-2. Effect of cool storage at 6°C on texture (N) of five strawberry cultivars.

pH and titrable acidity

The change in pH of strawberries as a function of storage time is shown in Figure-3.
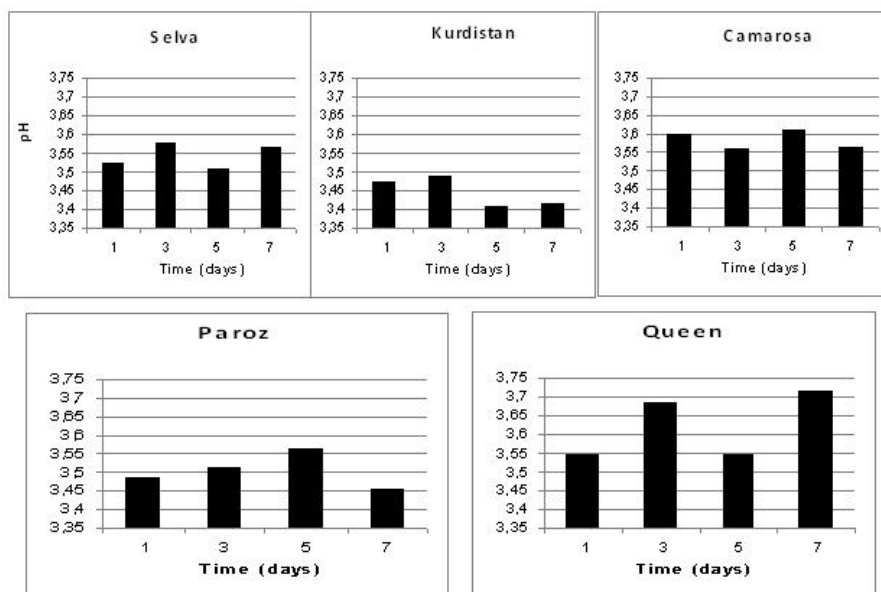
Figure-3. Effect of cool storage at 6°C on pH of five strawberry cultivars.

pH of all cultivars ranged between 3.41 and 3.72, values that were above the average for ripe strawberry, pH of 3.3 (Green ,1971). Kurdistan cultivar had a lower pH than the other samples during cool storage. The percentages of titrable acidity (TA), in all studied cultivars were between 0.52 and 0.86 during the storage period (Figure-4). These values are close to the value mentioned in the literature between 0.6 and 2.3% Green (1971). Marked changes in citric acid content were observed during fruit storage at cool temperature. Except for Paroz, all cultivars had a higher acidity than the initial period at the end of storage time. After the 7 days of storage time, acidity level between Camarosa,

and Queen and between Kurdistan and Selva was not significantly different ($\alpha = 0.05$).

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 colour of the fruit. However, there is little published information about changes of pH and TA content in strawberry fruit stored at low temperatures. According to Nunes *et al*. (1995), cultivars 'Chandler', 'Oso Grande' and 'Sweet Charlie', stored at 1°C, showed

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no differences in pH, but TA was slightly lower after 1 week. Remarkable changes of pH and citric acid content were observed by (Gil *et al*., 1997) in stored strawberries of 'Selva' cultivar at 5 ºC under different concentrations of CO_2 for 10 days. However, it was concluded that the effect was probably a consequence of the CO_2 since the increase of pH (and the decrease of TA) was paralleled by the increase in concentration of CO_2 in the atmosphere.

The results of our study (Figures 3 and 4) clearly indicate that changes in pH and citric acid content during storage can also depend on cultivar. This information is important if there is a correspondence between the observed change in composition and fruit taste, since organic acids are one of the main components of strawberry flavor.
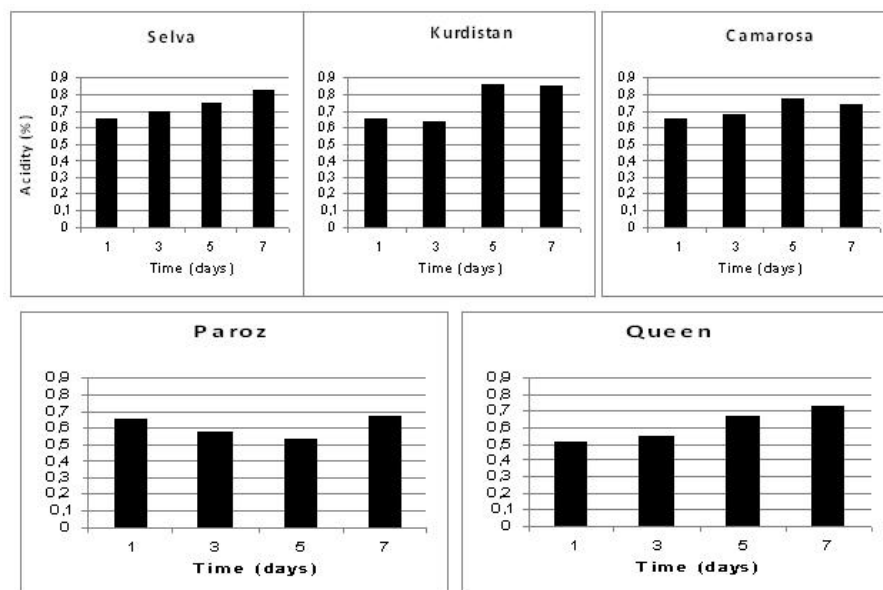
Figure-4. Effect of cool storage at 6°C on acidity (%) of five strawberry cultivars.

Total soluble solids and total sugar

The initial values for TSS ranged from 8.5 to 15 on the first day of storage in all cultivars. Changes in the soluble solids content of strawberries with storage time are shown in Table-1.

Table-1. Total soluble solids (TSS) (%) and total sugar (TS) (g/100 g) during storage of five strawberries cultivars.

Days	Paroz		Camarosa		Kurdistan		Selva		Queen	
	TSS	TS	TSS	TS	TSS	TS	TSS	TS	TSS	TS
1	10.9± 0.1	6.1± 0.13	11.93± 0.2	9.9± 0.11	8.68± 0.12	5± 0.15	10.7± 0.3	5.2± 0.9	14.32± 0.2	5.5± 0.12
3	10.7± 0.3	6.93± 0.1	11.92± 0.1	7.6± 0.13	8.7± 0.2	5.7± 0.13	12.1± 0.15	6.9± 0.1	10.32± 0.14	6.65± 0.1
5	9.41± 0.21	7.1± 0.1	12.13± 0.3	7.7± 0.12	8.46± 0.11	5.7± 0.16	9.4± 0.2	5.9± 0.1	11.41± 0.1	7.46± 0.3
7	11± 0.1	10.3± 0.2	11.74± 0.1	8.3± 0.1	9.8± 0.14	6.4± 0.11	11.84± 0.1	7± 0.2	14.67± 0.18	6± 0.21

Values are mean ± s.d; n = 3.

The results showed that changes in TSS during storage time vigorously depend on cultivar. The total soluble solid of mature strawberries has been reported to decrease under cold storage as a result of respiration (Garcia *et al*., 1998). By contrast, the results obtained from

Hernández-Muñoz *et al*. (2006) indicated that TSS increased with time. They explained changes by the considerable loss of water by strawberries during storage at 20 ºC. The change in TSS content was mainly higher in Queen during storage time. After the 7 days of storage,

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TSS level between Camarosa and Selva was not significantly different ($\alpha = 0.05$). Since sucrose is the primary source of glucose and fructose, the increased amount of these monossacharides could account for the decrease in sucrose level. However, the TSS increase indicates that sucrose synthesis had taken place during cool-storage.

At day 1, the amount of total sugar was below 7g/100g for Selva, Kurdistan, Paroz and Queen, while Camarosa had value above 9.5g/100g. Table-1 shows that the TS were changed during the cold storage in all cultivars. Throughout the storage period the TS value was increased in all of them and except of the Camarosa fruits, the final sugar contents were higher than that of the first day. Since strawberry does not have starch to support soluble sugar synthesis after harvest, this increase may be a consequence of cell-wall degradation.

Sensory scores

Sensory property (flavor) of strawberry cultivars on 1 and 7 days are shown in Figure-5. The sensory score of Paroz, the Queen and Kurdistan strawberry samples changed during storage with a different trend for all the treatments. After 7 days of storage, reduction was more noticeable in Kurdistan cultivar. The flavor evaluation results showed that the sensory score of Camarosa and Selva did not affect significantly by storage time. The sensory score of these two cultivars was highest among studied cultivars.
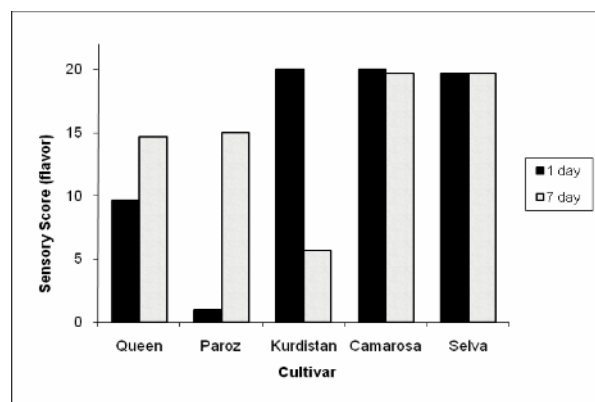
Figure-5. Effect of cool storage at 6°C on sensory score (flavor) of five strawberry cultivars.

CONCLUSIONS

As discussed above, lowering the storage temperature is an effective way to extend the strawberry shelf-life, maintaining the fruits edible for additional days. However, temperature can also induce small changes in some of the quality parameters studied. The data obtained reveal the importance of the cultivar in question since there were some contrasting responses among the varieties. Also, the initial values for some of the parameters were clearly different, indicating that the cultivar of strawberry is the most important factor in determining post-harvest quality and extended shelf-life. This idea is reinforced by the data related to fruits cultivated at the same time under the same growing conditions.

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