

## Efficacy and inefficacy of refrigerated storages on some physical, physiochemical and electrochemical properties for organically-grown 'Royal Glory' and 'Redhaven' peaches

M. Ergun

(Received April 29, 2011)

### Summary

The study focused on organically-grown 'Royal Glory' and 'Redhaven' peaches, with the aim to evaluate some physical, physiochemical and electrochemical quality indices during and after refrigerated storages at 0, 5 and 12 °C for up to 12 days and subsequently 1 day at 25 °C. Peaches lost their fresh weight and firmness during the storages regardless of the storage temperatures and cultivars; however, the loss in firmness for peaches at 12 °C was extensive, which delimited to durations of the storage. Marked changes in peel and flesh color, soluble solids content, titratable acidity, and vitamin C content were also registered over the storage time. Both cultivars developed chilling injury symptoms as internal flesh browning at 0 °C rather than at 5 °C which supported by a decrease in chromatic L\* and b\* values. For the first time, electrochemical parameters such as redox potential and P-value for a peach fruit using Bioelectric Vincent method have been reported and evaluated. However, no significant relationship was found between electrochemical and other physiochemical quality parameters assessed.

### Introduction

Consumer demand for high-quality fresh fruits is constantly increasing, thus, it is important to define fruit quality on basis of consumer requirements and acceptances. For a favorable purchase decision, visual appeal of a fruit is a primary criterion including size, color, shape, absence of defect and homogeneity. External appearance is frequently addressed as "quality" and is the main target of many fruit breeding programs, and peach is not an exemption (PREDIERI et al., 2006). The appearance of a peach fruit, however, does not alone guarantee for consumer satisfaction and repeat sales since internal quality, mainly defined by its taste, is also a very important criterion. Internal quality mainly depends on flesh color, uniformity, free from defects, texture, sugars, acids, phenolics, aromatic compounds etc. Several physical and physicochemical methods are used to determine internal quality, which frequently requires expensive laboratory instruments, trained personal and time. One of the easiest ways to measure internal peach fruit quality could be use of Bioelectric Vincent method which has been tested by German and Austrian researchers for three decades (HOFFMAN, 1991; KEPPEL, 1998; MELTSCH et al., 2005). The method developed by a French hydrologist Jean-Claude Vincent in 1935 is based on the three basic factors pH, redox potential (rH in mV) and resistivity (R in  $\Omega$ ), the reciprocal of electrical conductivity, indicating the activity of electrons (KAPPERT and MELTSCH, 2007). In plants life, biochemical processes can be described as redox reactions derived from the activity of electrons (GAJEWSKI et al., 2007). P-value has been generally used as one of the quality parameters for degrading products; it is now being tested as an integrative method of fruit quality assessments. According to Bioelectric Vincent method, better product quality or recovered products showing a low redox potential and P-value but a higher resistivity (WOLF and REY, 1997). Bioelectric Vincent method has been tested and found useful for few

fruits and vegetables including apples (HOFFMANN, 1991; KEPPEL, 1998), oranges (HOFFMANN, 1991), plums (ERGUN and JEZIK, 2011), strawberries (WEISSINGER et al., 2008), pumpkins (PAULAUSKIENE et al., 2006), carrots (VELIMIROV, 2004, 2005; GAJEWSKI et al., 2007) and tomatoes (AKAY and KARA, 2006; KAÇIU et al., 2010).

Peaches have a limited postharvest life due to rapid ripening and deterioration processes at ambient temperature. Therefore, low temperature storages are recommended to delay these processes, and eventually prolonging the postharvest life. However, prolonged cold storages can lead to chilling injuries. Chilling injuries are triggered and influenced when the peaches are stored for extended periods at near to 0 °C (FERNÁNDEZ-TRUJILLO and ARTÉS, 1998). On the other hand some researches state that, depending on the cultivar and maturity, chilling injury symptoms develop more distinctly when peaches are refrigerated at temperatures in the range 2 - 8 °C (NANOS and MITCHELL, 1991; CRISOSTO et al., 1999; MANGANARIS et al., 2006). These symptoms are mealy or woolly texture (mealiness or woolliness), hard texture with no juice (leatheriness), flesh or pit cavity browning (internal browning), flesh bleeding (internal reddening) and off-flavor development (LURIE and CRISOSTO, 2005). The symptoms usually develop after cold storage regimes; therefore, the problem may not benoticed until the fruits reach consumers (CRISOSTO et al., 1999). Bioelectric Vincent method would be a novel and simple way to detect whether peaches stored at chilling temperature storages develop chilling injuries before reaching the customers.

The objective of the present work is first to evaluate and compare some physical, physiochemical and electrochemical quality indices for organically-grown 'Royal Glory' and 'Redhaven' peaches using Bioelectric Vincent method during and after storage at 0, 5 or 12 °C, and second to identify whether refrigerated peach fruits developed chilling injury symptoms which can be noticed immediately by using the Bioelectric Vincent method. To our knowledge, this is the first report on measuring electrochemical peach fruit quality applying Bioelectric Vincent method.

### Materials and methods

#### Plant material and storage regime

Organically-grown peaches (*Prunus persica* L. Batsch L. 'Royal Glory' and 'Redhaven') were harvested by hand from 5-year old trees on the rootstock 'Cadaman' at commercial maturity stage according to fruit size and skin backgrounds ('Royal Glory' of SSC: 9.96%, TA: 0.56%, firmness: 71.02 N; 'Redhaven' of SSC: 10.56%, TA: 0.51, firmness 83.50) from the experimental orchard of the University of Natural Resources and Life Sciences in Vienna (latitude: 48° 17'9" N; longitude: 16° 25'31" E; elevation circa 200 m). Only fruits of uniform size, free from visual symptoms of disease or blemish were used for the present experiment. The fruits were transported to the postharvest laboratory of the Institute where they were randomly dived into 3 batches containing each approximately 100 fruits. The first batch was stored in a cold room at 0 °C, the second batch in a

cold room at 5 °C, and the third batch in a cold room 12 °C. Before the storages, the fruits were placed in plastic trays (36 fruits per tray) in commercial cardboard boxes (29.5 cm wide by 50.00 cm long by 10.0 cm high; one tray per box). The fruit were removed from the cold storage every 3 d for up to 4 removals, and indented to keep for 12 d in the cold rooms plus 1 d at 25 °C, however, the fruits at 12 °C were removed from the cold room after day 3 due to extensive decay rates while others were kept for 12 d.

### Firmness and weight loss

Fruit firmness was measured on the equatorial zone of the both cheeks after removing fruit skin using a Mecmesin Microprocessor Force Gauge (M 1000E, Henko (S) Pte Ltd., Singapore). The convex probe tip was penetrated into fruit flesh 5 mm at top speed of 10, and the reading was recorded as Newton (N). Ten of the stored fruits were removed for measurements at 3-day intervals plus 1 d at room temperature for 12+1 d.

Weight loss was determined considering the fresh weight at harvest using a balance with an accuracy of 0.01 g (A&D FX-3000i, Japan). Weight loss was then calculated from the weight of each peach measured initially before storages and after 3, 6, 9 and 12 d.

### Soluble solids content, titratable acidity and vitamin C

Deseeded peach fruits were passed through an electric juicer (Moulinex, 733, France) and filtered through a Whatman No 4 filter paper for the measurement of soluble solids content (SSC), titratable acidity (TA) and vitamin C content. SSC was measured by a digital refractometer (Atago, Palette, PR-100, Japan). TA was determined by titration of 5 ml juice diluted with 25 ml distilled water to pH 8.2 with 0.1 N NaOH and expressed as percentage malic acid. For the titration, an automatic titrator (Schott, TA 20 Plus, Germany) was employed. Vitamin C content was assessed by a digital reflectometer (Qflx 10, Merck, Germany) equipped with ascorbic acid test strips (Merckoquant Ascorbic Acid Test, Cat. No. 1.10023.001, Merck, Germany) and expressed as mg l<sup>-1</sup> L(+)-Ascorbic acid. All the measurements were employed at room temperature.

### Instrumental color

Fruit skin color was assessed on the equatorial zone of the both cheeks using a Minolta CR-100 colorimeter, calibrated with a white reference plate. Measurements were recorded using standard CIE L\* a\* b\* color space coordinates. Fruit flesh color was measured on the half-cut fruit wedge with the same instrument and method mention above.

### Chilling injury

Ten fruits from each storage regime were removed every 3 d, and stored at 25 °C for 1 d to evaluate chilling injury symptoms as internal flesh browning. Flesh browning of the mesocarp tissue was estimated visually by comparison to an arbitrary 10-point reference scale on the cut surface of a fruit (each side of the wedge estimated and the mean was taken), consisting of 0, 10, ... 100% of the maximal extent of internal browning typically seen (BRUMMELL et al., 2004).

### Electrochemical values

Redox potential (mV), pH, P-value (μW) and resistivity (ohm, Ω) were assessed from the juice prepared for the previous physiochemical analysis by a digital electrochemical quality assessment device (BE-

T-Analyse Prof. n. Vincent, MED Tronik, Germany) with processing through a software (Med-Tronik, Terrainanalyse 2.2, Germany). Circa 30 ml fruit juice in a 50-ml beaker on a magnetic stirrer was used to measure the aforementioned values.

### Treatment design and statistical analyses

The experimental design was set as Completely Randomized Design with 10 replicates. Analysis of variance (ANOVA) and LSD multiple range test of significant difference ( $p \leq 0.05$ ) was performed. Statistical analyses were carried out by SAS software (release 9.1.3, SAS Institute Inc., Cary, North Caroline, USA).

## Results and discussion

### Firmness and weight loss

Peaches softened at different rates during the period of the storage regardless of the cultivars and the storage temperatures (Fig. 1). The 12 °C storage regime caused an excessive firmness loss for both cultivars, dropping firmness values below 10 N just after 3+1 d. The 5 °C storage regime also caused a severe firmness loss but only in 'Royal Glory' peaches and only after 6+1 d. After 12+1 d, fruit stored initially at 0 °C exhibited lowest firmness loss for 'Royal Glory' whereas fruits stored initially at 5 °C did the lowest loss for 'Redhaven'. Fruits from both peach cultivars stored at 0 °C exhibited a marked retention of firmness compared to fruits stored at 12 °C which may be ascribed to reduced activities of fruit softening enzymes. Both cultivars had a constant weight loss over time during storage by having an insignificant temperature effect on them (Fig. 1). The weight loss ratios were however higher for 'Royal

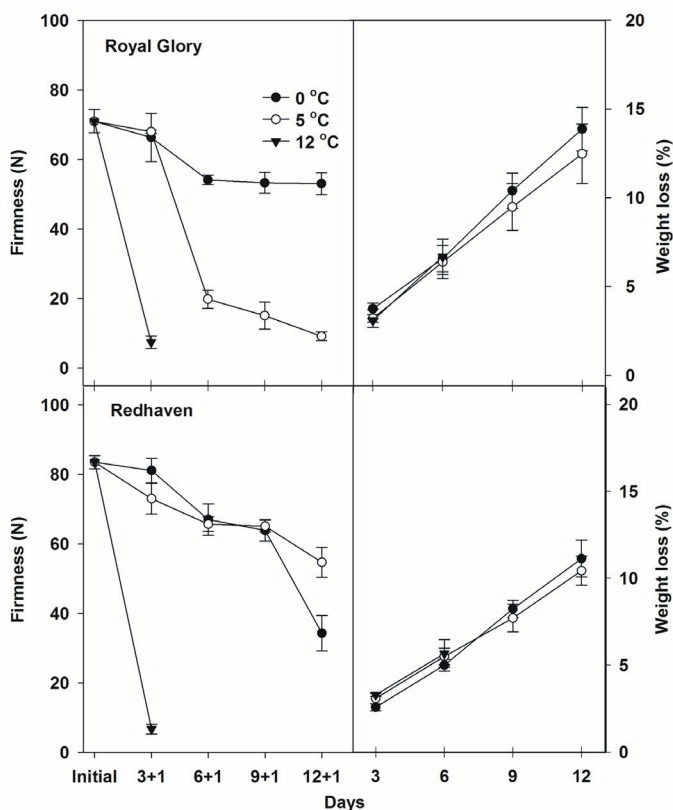


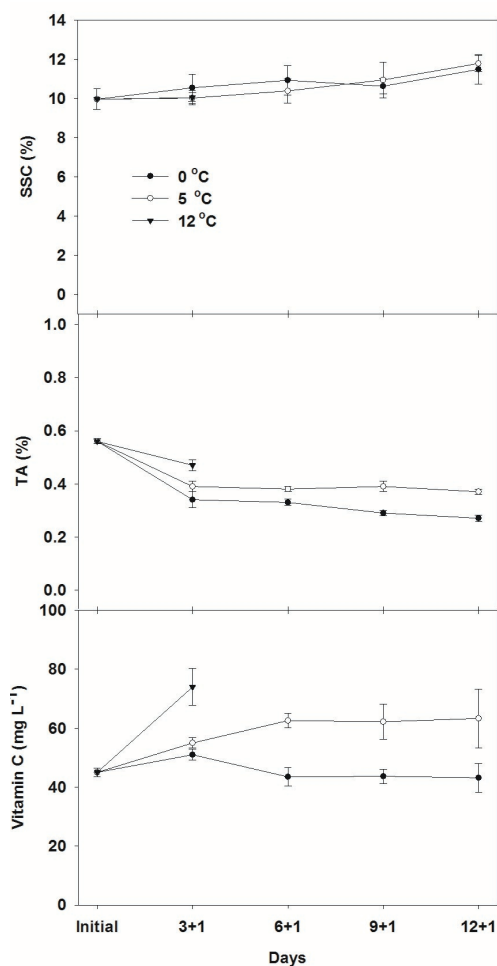
Fig. 1: Changes in weight loss for 'Royal Glory' and 'Redhaven' peaches during storage at 0, 5 and 12 °C, and in firmness during storage at 0, 5 and 12 °C plus 1 d at 25 °C. Vertical bars represent standard error of means.

Glory' peaches compared to 'Redhaven' peaches regardless of storage temperatures. The increase in weight loss in cold storage is partially attributed to the vapor pressure deficit in the storage rooms (DAGAR et al., 2011).

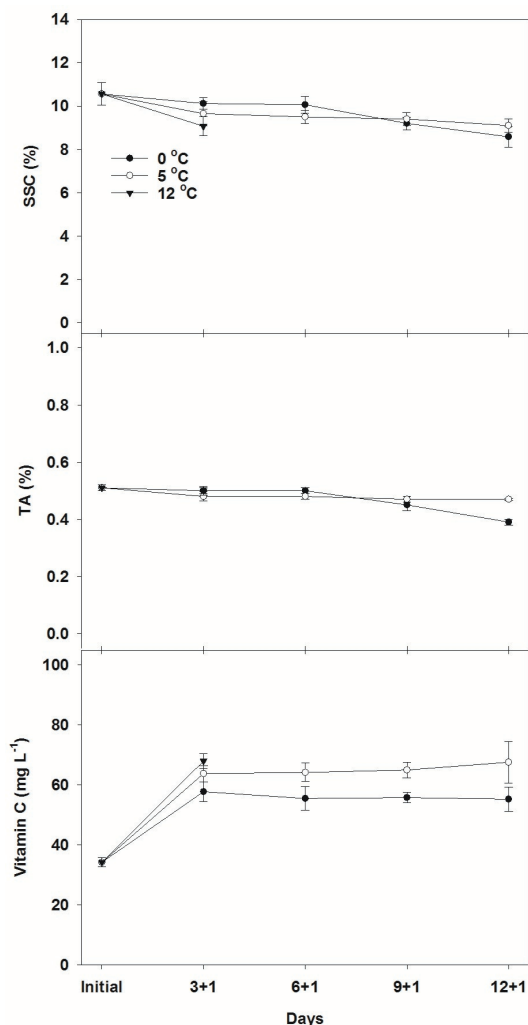
### Soluble solids content, titratable acidity and vitamin C

SSC from 'Royal Glory' peaches increased diminutively but insignificantly among treatments from approximately 10 to 11% over time (Fig. 2). TA from 'Royal Glory' peaches slightly decreased during the period of storage regardless of storage temperatures. After 12+1 d, fruits from 'Royal Glory' at 5 °C exhibited a lower loss in TA values than fruits at 0 °C, leading to a significant difference between the two treatments. This difference may be due to an alteration in some aspect of malic acid (the major organic acid in peaches) synthesis, metabolism, or vacuolar compartmentalization (YEN, 1987; CAMPBELL and KOCH, 1989; WEN et al., 1995), all of which are affected by low temperatures. The increase in SSC and the decrease in TA for 'Royal Glory' at 0 °C were also reported by MANGANARIS et al. (2008). Vitamin C content (circa 33 mg L<sup>-1</sup> at harvest) from 'Royal Glory' first increased irrespective of the temperatures then decreased in fruits stored at 0 °C, and continued to increase in fruits at 5 °C, generating marked differences among treatments (Fig. 2).

SSC from 'Redhaven' peaches declined with storage duration irrespective of storage temperatures from approximately 11 to 9 %



**Fig. 2:** Changes in soluble solids content (SSC), titratable acidity (TA) and vitamin C content for 'Royal Glory' peaches during storage at 0, 5 and 12 °C plus 1 d at 25 °C. Vertical bars represent standard error of means.



**Fig. 3:** Changes in soluble solids content (SSC), titratable acidity (TA) and vitamin C content for 'Redhaven' peaches during storage at 0, 5 and 12 °C plus 1 d at 25 °C. Vertical bars represent standard error of means.

(Fig. 3). TA from 'Redhaven' peaches also decreased over time while the decrease higher in fruits stored at 0 °C than fruits stored at 5 °C at the end of the storage period (Fig. 3). Vitamin C content was approximately 43 mg L<sup>-1</sup> at harvest, and then slightly increased in all cold-stored fruits followed by a steady-state for those fruits stored at 5 °C or by a slight decrease for those fruits stored at 0 °C (Fig. 3). At the end of the storage period, fruits stored at 5 °C had a statistically higher SSC, pH and vitamin C level than fruits stored at 0 °C did.

### Instrumental color

Color changes in fruit skin and flesh for 'Royal Glory' peaches are presented as L\*, a\* and b\* values (Fig. 4). Fruit skin and flesh tissue color changed throughout storage period with exception of flesh a\* value for the fruits stored at 5 °C in which the color value remained constant. L\* values in both fruit skin and flesh decreased over time but decrease was higher in peaches stored at 0 °C than peaches stored at 5 °C. With the exception of flesh a\* value for fruits stored at 5 °C, a\* value for both fruit skin and flesh also decreased in all peaches over time. Chromatic b\* values in fruit skin decreased regardless of storage temperatures as well but in fruit flesh either increased (fruits at 5 or 12°C) or decreased (fruits at 0 °C). With respect to color L\*, a\* and b\* values, storage at 5 °C significantly suppressed the color

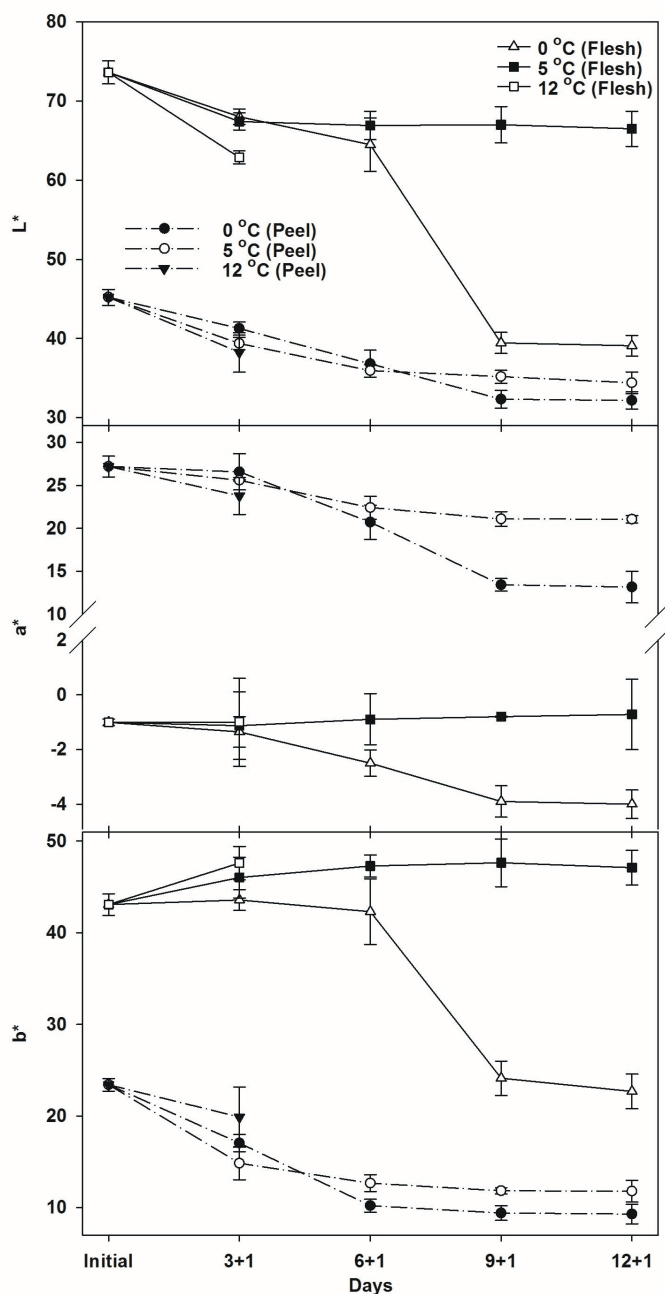


Fig. 4: Changes in instrumental colors for 'Royal Glory' fruit skin and flesh during storage at 0, 5 and 12 °C plus 1 d at 25 °C. Vertical bars represent standard error of means.

lessening, causing a statistical difference between fruits stored at 0 and 5 °C after 12+1 d storage period.

Fruit skin color values presented in the form of  $L^*$ ,  $a^*$  and  $b^*$  for 'Redhaven' peaches gradually decreased over time (Fig. 5). The decrease was however extensive in fruits stored at 0 °C compared to fruits stored 5 °C causing a statistical difference after 9+1 d in  $a^*$  and  $b^*$  value. Color parameters of  $L^*$ ,  $a^*$  and  $b^*$  for flesh tissue changed overtime as well (Fig. 5). The change in  $L^*$  was a decrease, in  $a^*$  an increase and in  $b^*$  an increase followed by a decrease. The most notable effect of the storage regimes on flesh color was observed on  $L^*$  value whose lessening was markedly suppressed by the 5 °C storage regime. The 5 °C storage regime, on the other hand, caused a

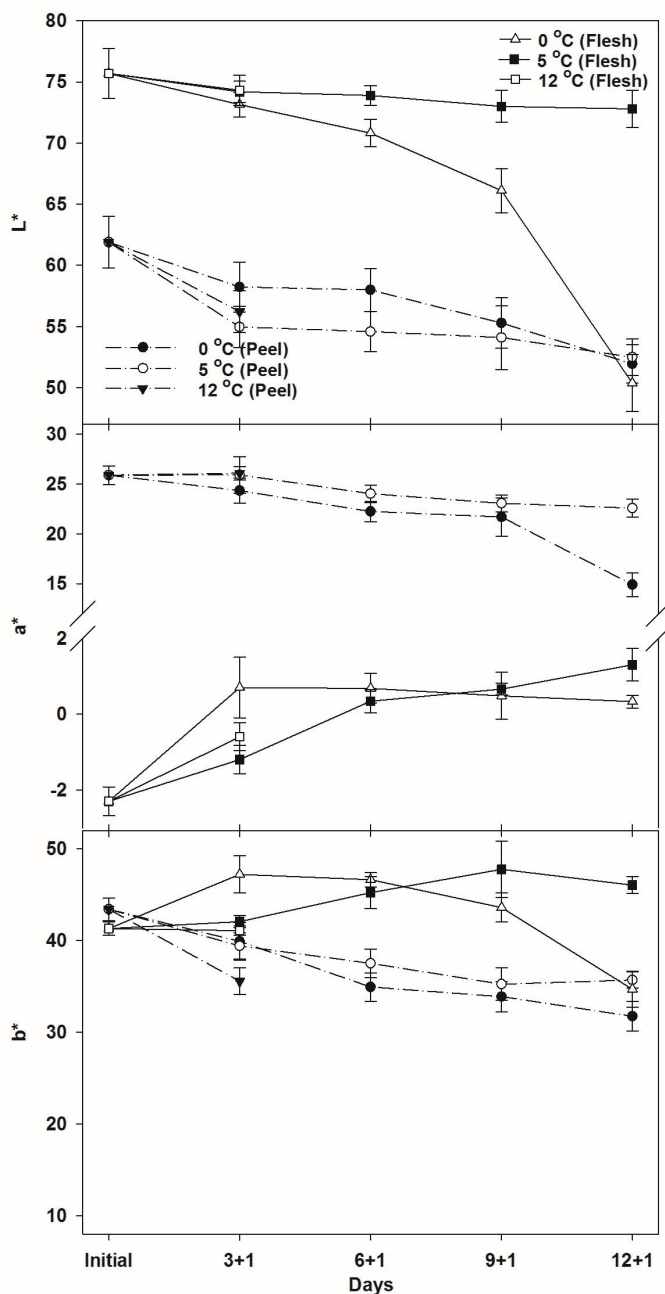
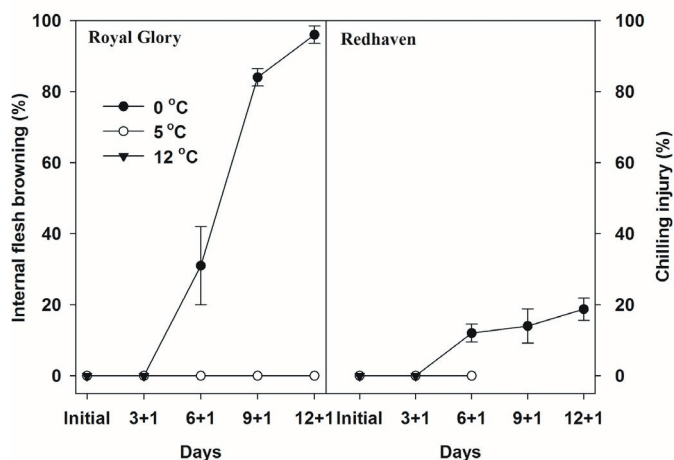


Fig. 5: Changes in instrumental colors for Redhaven' fruit skin and flesh during storage at 0, 5 and 12 °C plus 1 d at 25 °C. Vertical bars represent standard error of means.

marked increase in both flesh  $a^*$  and  $b^*$  values compared to the 0 °C storage regime over time.

Both cultivars generally responded to the very low temperature storage (0 °C) by accelerating the lessening fruit skin and flesh  $L^*$ ,  $a^*$  and  $b^*$  values aside from flesh  $a^*$  value for the 'Redhaven' fruits. The lowering in  $L^*$  value from fruit flesh may indicate browning which is possibly caused by chilling injuries. The decrease in  $b^*$  value may suggest a color loss possibly due the increase membrane permeability which is a typical symptom of chilling injuries. The instrumental color assessment clearly reveals that the chilling temperature storage (0 °C) may cause significant color lessening for both 'Royal Glory' and 'Redhaven' peaches leading to an inferior





**Fig. 6:** Changes in internal flesh browning as a chilling injury symptom for 'Royal Glory' and 'Redhaven' fruit flesh during storage at 0, 5 and 12 °C plus 1 d at 25 °C. Vertical bars represent standard error of means.

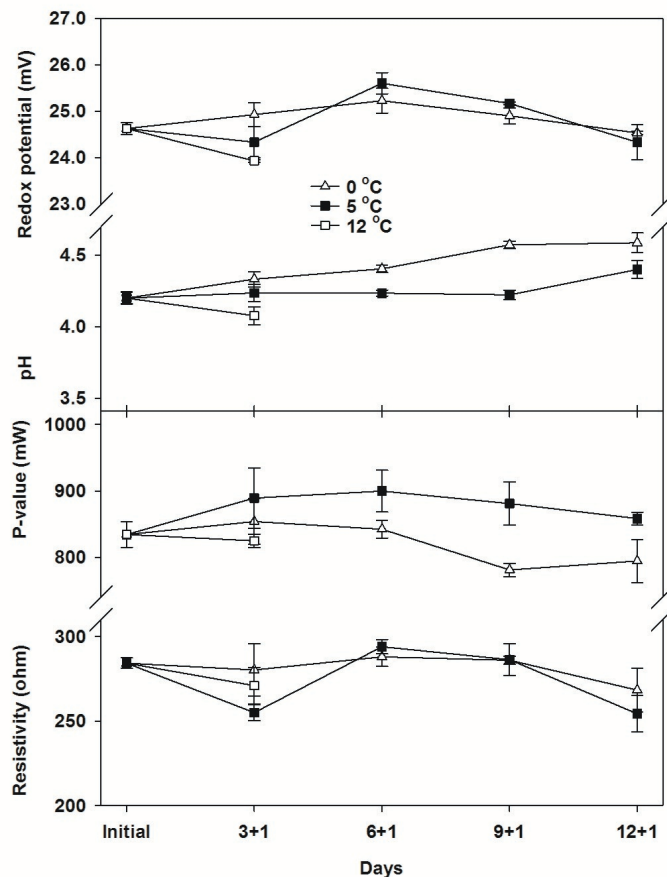
fruit quality as opposed to the low degree (5 °C) temperature storage.

### Chilling injury

No chilling injury (CI) symptoms as internal flesh browning for either cultivar were detected before day 6+1 regardless of the temperatures (Fig. 6). Afterwards, CI symptoms for 'Royal Glory' fruits at 0 °C manifested reaching nearly 100% at the end of the storage period while CI symptoms for 'Redhaven' fruits at 0 °C expanded only up to 20% at the end. Neither 'Royal Glory' nor 'Redhaven' peaches at 5 °C developed CI symptoms but only fruits stored at 0 °C. In contrast, MANGANARIS *et al.* (2008) have shown that 'Royal Glory' fruits stored 6 weeks at 0 °C plus 5 d at 25 °C did not develop chilling injuries. Contrary many previous report, both 'Royal Glory' and 'Redhaven' stored at 0 °C developed more chilling injury symptoms in the form of internal flesh browning than fruits stored at 5 °C. This discrepancy could be due to the rootstocks and/or ecological condition where trees are planted. A comparable work to the present study has been reported by CERETTA *et al.* (2000) in which 'Eldorado' fruits kept at -0.5 °C developed less flesh browning than fruits kept at +0.5 °C. Chilling injury in fruit has been found to be associated with the modification in membrane permeability (WANG, 1989). The bilayer made up membrane can adopt a solid gel phase state at lower temperatures, in return may cause the metabolism imbalance, cell autolysis and finally development of CI symptoms at 0 °C had severe CI symptoms even after 6+1 d compared to 'Redhaven' peaches. Antioxidant capacity of 'Redhaven' has been found higher than that of 'Royal Glory' peaches (TAVARINI *et al.*, 2008). Taken together the data of TAVAR (WANG, 1989), LURIE and CRISOSTO (2005) have further suggested that the flesh browning disorder may be related to tissue deterioration or senescence, which leads to changes in membrane permeability and the interaction between phenols and polyphenol oxidase, which are generally found in separate compartments in the cell. In the present experiment 'Royal Glory' peaches INI *et al.* (2008) and these presented here rise the possibility that 'Redhaven' develops less chilling injuries than 'Royal Glory' peaches do due to higher antioxidant capacity of 'Redhaven' peaches.

### Electrochemical values

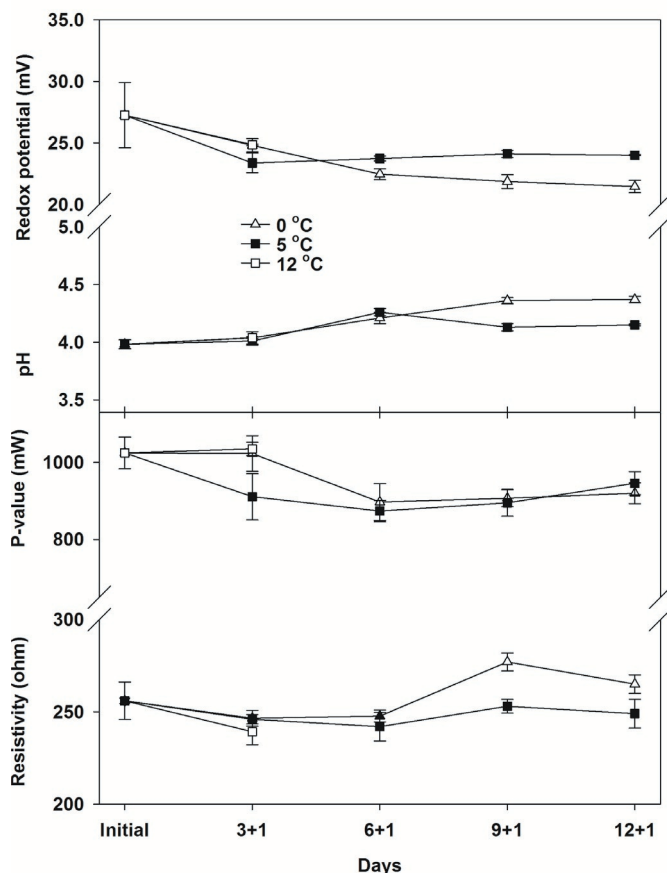
Redox potential values in 'Royal Glory' peaches evolved differently during the storage (Fig. 7). During the course of the storage, the



**Fig. 7:** Changes in redox potential, pH, P-value and resistivity (R) for 'Royal Glory' peaches during storage at 0, 5 and 12 °C plus 1 d at 25 °C. Vertical bars represent standard error of means.

values in fruits stored at 12 °C decreased, in fruits stored at 5 °C initially decreased, then increased and finally decreased again, in fruits stored at 0 °C remained almost constant. With the exception of values of fruits that were stored at 12 °C, pH values in fruits stored at 0 or 5 °C slightly increased over time (Fig. 7). The increase was however higher in fruits stored at 0 °C than in fruits stored at 5 °C, causing a marked difference between them. P-value in fruits stored at 12 °C remained constant during period of storage (3+1 d) whereas in fruits stored at 0 or 5 °C first slightly increased then decreased over time (Fig. 7). The ensuing decrease was sharper in fruits stored at 0 °C than in fruits stored at 5 °C, resulting in a statistical difference between them. Resistivity values initially decreased in fruits irrespective of storage temperatures, and then the values increased in fruits stored at 0 or 5 °C followed by decrease at the end of the experiment, eventually leading to lower values compared to the initial values (Fig. 7). There were no consistent differences in resistivity values among the peaches stored at 0, 5 or 12 °C.

Changes in redox potential, pH, P-value and resistivity in 'Redhaven' peaches during storage are shown in Fig. 8. Redox potential values in all 'Redhaven' peaches decreased over time regardless of storage temperatures but the decrease rate was higher for those peaches stored at 0 °C than peaches stored at 5 °C, resulting in a marked difference between them. In all peaches stored at 0, 5 or 12 °C, pH initially and slightly increased, then continued increase in fruits stored at 5 °C while slightly decreased in fruits stored at 0 °C after 6+1 d. The subsequent decrease after 6+1 d in pH values in the peaches stored at 0 °C caused a marked difference between peaches kept at 0 and 5 °C. P-value remained constant in peaches kept at



**Fig. 8:** Changes in redox potential, pH, P-value and resistivity (R) for 'Redhaven' peaches during storage at 0, 5 and 12 °C plus 1 d at 25 °C. Vertical bars represent standard error of means.

0 or 12 °C during the first 4 d (3+1) of the storage period while it decreased in fruits kept at 5 °C during the first 7 d (6+1) followed by a slight increase. P-value in fruits stored at 0 °C decreased after 4 (3+1) d, then moderately increased. There were no differences in P-value among fruits kept at 0, 5 or 12 °C during the period of the cold storage. The resistivity values initially decreased, and then increased through the end of the storage period for all 'Redhaven' peaches (Fig. 8). The subsequent increase in the resistivity value from fruits stored at 0 °C was however higher than that of fruits stored at 5 °C leading a marked difference between them.

Correlation coefficient  $r$  values between selected electrochemical and physiochemical parameters are shown in Tab. 1. For 'Royal Glory', a negative moderate correlation between vitamin C and pH; a positive moderate correlation between redox potential and P-value, and redox potential and resistivity; and a strong negative correlation between pH and TA were calculated. For 'Redhaven', a negative moderate correlation between vitamin C and redox potential, vitamin C and resistivity, and TA and P-value; a positive moderate correlation between vitamin C and pH were recorded. Both cultivars had dissimilar correlations from each other.

According to Bioelectric Vincent method, good quality is expected to achieve with a low redox potential and P-value as well as higher resistivity. 'Royal Glory' peaches responded differently to the storage temperatures compared to the initial values at harvest. At the end of the experiment, P-value for 'Royal Glory' peaches stored at 0 °C was lower than the initial level and fruit at 5 °C which is a desired feature according to Bioelectric Vincent method. The pH value of 'Royal Glory' peaches, nevertheless, increased over time

**Tab. 1:** Correlation coefficients  $r$  between selected electrochemical and physiochemical characteristics of 'Royal Glory' and 'Redhaven' peaches.

Parameters	Redox potential	pH	P-value	Resistivity
<b>'Royal Glory'</b>				
SSC	-0.07	0.31	-0.13	-0.13
TA	-0.19	-0.76**	0.08	0.17
Vitamin C	-0.24	-0.45*	-0.12	0.10
Redox potential	-	0.20	0.57*	0.46*
pH	-	-	-0.08	-0.30
P-value	-	-	-	-0.30
<b>'Redhaven'</b>				
SSC	0.33	-0.22	0.18	0.00
TA	-0.31	0.00	-0.51*	0.00
Vitamin C	-0.48*	0.55*	0.17	-0.47*
Redox potential	-	-0.36	0.12	0.27
pH	-	-	0.32	-0.30
P-value	-	-	-	-0.23

\* means a moderate correlation; \*\* means strong, high correlation

which is an undesired development. Because pH expresses the level of active protons and shows the energetic aspects of life process (GAJEWSKI et al., 2007), and a rise in pH values means a loss of vitality in plants (DANIELCENKO et al., 2005). 'Redhaven' peaches responded also differently to the storage temperatures compared to the values at harvest. After 12+1 d of storage, 'Redhaven' peaches stored at 0 °C had higher resistivity values while lower redox potential implying that the fruits were in well condition. But fruits of 'Redhaven' at stored 0 °C had higher pH values than fruits at harvest did, again not supporting the previous assumption. Thus, Bioelectrical Vincent method alone itself seems to be insufficient for differentiating between peaches subject to low temperature storage (5 °C) and chilling temperature storage (0 °C). On the other hand, other quality parameters including firmness, flesh color and internal flesh browning showed very significant differences between the two storage regimes. Unlike our study, product quality in connection with bioelectrical properties of organically-grown carrots and spinach are well documented (WALZ, 1996; KRAUTGARTNER, 2002; VELIMIROV, 2004). P-values have been found lower in organically grown carrots compared to conventionally grown carrots, which was interpreted a better quality (WALZ, 1996; VELIMIROV, 2004; VELIMIROV, 2005). KRAUTGARTNER (2002) and VELIMIROV (2004) also reported that organically-fertilized spinach had lower P-values. VELIMIROV (2004) further shown that organically-fertilized spinach had less dry matter loss claiming a longer shelf life. Previous studies have also confirmed that there is a correlation between P-values and plant health. For example, NAKVASIL (2004) reported that cucumber fruits inoculated with zucchini yellow mosaic virus had higher P-values compared to non-inoculated fruits indicating that a positive correlation between P-value and viral contamination.

## Conclusions

Both 'Royal Glory' and 'Redhaven' peaches showed some quality losses after prolonged refrigerated storages. Contrary to some previous reports both cultivars developed CI symptoms at 0 °C rather

than 5 °C as internal flesh browning supported by instrumental color measurement. These data were unexpected indicating that rootstock, ecology, growing conditions (conditional vs. organic) etc. greatly affect CI symptoms even on the same peach cultivar. For the first time, electrochemical parameters for peaches using Bioelectric Vincent method have been reported. However, Bioelectric Vincent method failed to identify CI symptoms for both peach cultivars grown organically.

### Acknowledgments

The author acknowledges financial support from the Scientific and Technological Research Council of Turkey (TUBITAK). The author thanks Karoline Maria Jezik for letting him use of her laboratory facilities, and Lucas Gach, Andreas Spornberger and Nazan Ergun for providing technical support and helps.

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Address of the author:

Muharrem Ergun, Department of Horticulture, Bingol University, 12000, Turkey.