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Quality Changes of three Strawberry Cultivars during the Cold Storage

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Summary

Quality changes of three strawberry cultivars ('Camarosa', 'Cavendish' and 'Chandler') packed with perforated plastic boxes during the cold storage (0 °C and 90–95 % relative humidity) were investigated. Weight loss of strawberries increased as a function of storage time. Strawberry fruits were firmer in cold-air storage than at harvest. Colorimeter values (L*, a*, b*, C* and hº) of strawberries stored 10 days decreased in comparison to initial values in all cultivars. Titratable acidity and vitamin C (ascorbic acid) contents of fruits decreased during the storage time. While the total soluble solid content of 'Cavendish' decreased, an increase was observed in 'Chandler'. Citric acid content showed an increase depending on storage time, whereas malic acid contents fluctuated during the storage period and decreased in all cultivars at the end of storage time. The postharvest life based on sensory evaluation was 10 days for 'Camarosa', 'Cavendish' and 'Chandler' fruits stored in cold air.

Zusammenfassung

Qualitätsänderungen von drei Erdbeersorten während der Kühllagerung. Untersucht wurden Qualitätsänderungen bei drei Erdbeersorten ('Camarosa', 'Cavendish' und 'Chandler'), die in perforierte Plastikboxen verpackt und kühl gelagert wurden (0 °C und 90–95 % relative Feuchte). Die Gewichtsverluste stiegen bei den Erdbeeren in Abhängigkeit von der Lagerdauer. Die Erdbeerfrüchte waren im Kühllager fester als zum Zeitpunkt der Ernte. Die Colorimeter-Werte (L*, a*, b*, C* und hº) aller drei Sorten waren nach 10-tägiger Lagerung geringer als zu Beginn. Der Gehalt an titrierbarer Säure und Vitamin C (Ascorbinsaäure) in den Früchten verringerte sich bei der Lagerung. Während der Gehalt an löslicher Trockensubstanz bei 'Cavendish' geringer wurde, konnte bei 'Chandler' ein Anstieg beobachtet werden. Der Zitronensäuregehalt fiel in Abhängigkeit von der Lagerdauer, wohingegen der Apfelsäuregehalt während der Lagerung schwankte und am Lagerende bei allen Sorten reduziert war. Die sensorische Beurteilung ergab, dass bei 'Camarosa', 'Cavendish' und 'Chandler' eine 10-tägige Kühllagerung ohne äußere Qualitätseinbuße möglich ist.

Key words. strawberry – cold storage – quality – firmness – flavour

Introduction

Strawberry (*Fragaria* x *ananassa* Duch.) fruits have unique, highly desirable taste and flavour and are one of the most popular summer fruits. Consumers mainly purchase strawberries to eat them with relish. Media reports have indicated increasing consumer dissatisfaction with the flavour and inconsistent quality of strawberries (FORD et al. 1997). The strawberry is a delicate and perishable fruit, susceptible to mechanical injury, physiological deterioration, water loss, and decay (BOYETTE et al. 1989; TALBOT and CHAU 1991). Temperature management is crucial in prolonging the postharvest quality of strawberries (HAGG et al. 1999). At high temperatures, respiration increases markedly, leading to a depletion of nutrient reserves, so that fruit senescence is accelerated. Even under low temperature and high relative humidity conditions, storage life is usually only about 7 days (BOYETTE et al. 1989; TALBOT and CHAU 1991). During the postharvest period of strawberries, rapid cooling and providing proper temperature (0 °C) and relative humidity (90–95 %) are the most important factors to prevent the undesirable quality changes. Besides its appearance (red colour intensity and distribution, fruit size and shape, free of decay), firmness and flavour (determined by amounts of sugars, organic acids, phenolics, and characteristic aroma volatiles) are the important factors for the quality of the strawberries (KADER 1990). Especially, the concentration of organic acids is an important factor influencing the organoleptic properties of fruits (LEE 1993).

Besides its good sensory features, consumers prefer strawberries because of its high content of vitamin C (SCHÖPPLEIN et al. 2002). It is one of the most important nutritional quality factors in strawberries, and many biological activities (reducing carcinogenesis and cardiovascular diseases, stimulating the immune system) in the human body (SIMON 1992).

Habitual postharvest practices used to control strawberry decay are based on the use of decreased temperatures (0–2 °C) and high CO_2 concentrations (up to 15–20 %). Carbon-dioxide-treated strawberries are firmer and less susceptible to decay than air-stored fruits (KADER 1992; SMITH 1992). However, the levels

of CO_2 and O_2 recommended to maintain strawberry quality are often too close to the limits of tolerance for this fruit, and detrimental effects, mainly on strawberry flavour, have been reported (SHAMAILA et al. 1992). On the other hand, several authors have reported increases in strawberry firmness by low temperature (LARSEN and WATKINS 1995; WATKINS et al. 1999). The mechanism by which both low temperature and CO_2 affect strawberry firmness is not yet understood. Since neither respiration rate nor ethylene production were directly related to the postharvest life, it was concluded that other factors play a role in determining the storage life of strawberries in air. For example, the effect of low temperature on the growth of microorganisms and fruit firmness may also influence the storage life of these fruits (PELAYO et al. 2002).

Almost all strawberries are stored at cold-air storages in Turkey because of the high cost prices of controlled atmosphere (CA) storage. Likewise, strawberries are commercially stored at 0 °C temperature and 90–95 % relative humidity conditions in many countries. For this reason, in this research cold air storage was used to investigate the quality changes of strawberries during the storage period.

Materials and Methods

The strawberry cultivars 'Camarosa', 'Cavendish' and 'Chandler' grown in the Research and Application Center of Horticulture Department in Isparta located at Mediterranean region of Turkey were harvested at the last periods of commercial ripeness (>75–80 % of the surface showing red colour). Freshly harvested fruits in the early morning were transported to the postharvest laboratory within a half an hour. Strawberries were sorted to eliminate fruits with defects including overripe or too small fruit. Fruits were selected randomly and placed in perforated (8 perforations, 10 mm diameter) plastic boxes of 750 g capacity as one replicate. Four replicates were used per treatment. Packaged fruits were stored at 0 °C temperature and 90–95 % relative humidity for 10 days. Strawberries taken from storage by 2–3 days intervals (initial, 2,5,7 and 10 days of storage) were analysed.

Weight loss

Weight losses of strawberries during the storage period were determined using a digital balance reading to 0.001 g. Some fruits placed in perforated plastic boxes for weight loss were weighted at the beginning of the experiment and at 2, 5, 7 and 10 days of storage. The results were expressed as percentage loss of initial weight.

Firmness

Fruit firmness was determined on 15 fruits (warmed to 20 °C) from each replicate by measuring penetration force with a universal testing machine (Lloyd LF Plus Universal Test Machine) equipped with a 5 mm probe. Two measurements were taken per fruit. A 50 kg loadcell was used for the firmness determination of fruits. Crosshead speed was 10 cm min^{-1} (NUNES et al. 1995). Data were recorded using the software Nexygen.

Total soluble solids (TSS), titratable acidity (TA) and pH-value

The juice of 15 fruits per replicate was analysed for TSS, TA, and pH. TSS was measured using a digital refractometer (Palette PR-32 ATAGO). TA was measured (titration to pH 8.1) using a digital brutte (Jencons Digitrate-50 ml) and a digital pH-meter (Hanna HI 9321 Microprocesor). TA was expressed as percent citric acid. The pH-value was determined by the same digital pH-meter.

Colour

The fruit samples were analysed initially and at 2, 5, 7 and 10 days of storage. Strawberries exhibiting any sign of decay were discarded. External colour was measured on opposite sides of 15 fruits using Minolta Chromameter (Model CR-300, Minolta) with Standard Illuminant C (average daylight not including UV) as light source. Before measurements the chromameter was calibrated by calibration plate. Colour was recorded using CIE L*, a* and b* values. These values were also used to calculate chroma ($C^* = [a^{*2}+b^{*2}]^{1/2}$) and hue angle ($h^o = \tan^{-1}[b^*/a^*]$), which represent the angle in a 360 ° colour wheel, where 0, 90, 180 and 270 represent red-purple, yellow, bluish green and blue, respectively (PEREZ and SANZ 2001).

Vitamin C (ascorbic acid) and organic acids

HPLC analysis was carried out to determine the vitamin C and organic acids on Shimadzu class LC VP HPLC system with class LC-VP software, a pump (LC-6AD), and a UV-VIS detector (SPD-10AV VP). The columns used were YMC Pack-ODS (250 mm x 4.6 mm I.D., 5 μm) for organic acids and SGE (250 mm x 4.6 mm I.D., 5 μm) for vitamin C. The mobile phases were water adjusted to pH 2.2 with trifluoroacetic acid (organic acids) and to pH 3 with phosphoric acid (vitamin C). Separation was carried out by isocratic elution with a flow rate of 0.4 ml min^{-1} and column temperature was ambient. The UV detector was set at 210 nm and 254 nm, respectively. Quantification was based on the peak area measurement.

Sample (10 g) was extracted in 10 ml water adjusted to pH 1.5 with trifluoroacetic acid for organic acids and with 10 ml phosphoric acid – water (2 %, v/v) for vitamin C. The extracts were filtered through filter paper. 1.5 ml buffer (0.01 M KH_2PO_4, pH 8.0) was added to 1.5 ml sample extract. 1.5 ml (organic acids) and 1 ml (vitamin C) of these mixtures were loaded to the C_{18} cartridges. After then, 3 ml water adjusted to pH 1.5 with trifluoroacetic acid for organic acids and 2 ml phosphoric acid – water (2 %, v/v) for vitamin C were loaded to the cartridges. 20 μl of the eluents were injected to HPLC.

Sensory evaluation

Fruit samples of 'Camarosa', 'Cavendish' and 'Chandler' were randomly selected at the beginning and at 2, 5, 7 and 10 days of storage. In sensory evaluation, hedonic scales were used. 5 panellists (scientists in the horticulture department) evaluated the strawberries for

marketable quality (fungal decay, appearance and texture) and flavour. Strawberry fruits showing surface mycelial development were considered decayed. Sensory evaluations were conducted in a special facility fitting the standard requirements for a testing room: booths with partitions to eliminate panellist interaction and facilitate concentration, quiet, odour free, and illuminated with a fluorescent lamp. Samples were presented in identical containers. The order of presentation to each judge was randomized. Flavour was scored in a scaling test by using a 5 points scale (1 = poor and 5 = very well) and a 9 points scale for the marketable quality (1–3: unacceptable, >3–<7: acceptable and 7–9: excellent).

Statistical analysis

Statistical analysis of data was performed using analysis of variance. Duncan's multiple range test was applied in order to compare the means where statistical differences ($P<0.05$) were detected.

Results and Discussion

Weight Loss

Weight loss of strawberries in perforated plastic boxes increased as a function of storage time for all cultivars. The effect of storage time on weight loss was statistically significant. At the end of the storage period, weight losses of 'Camarosa', 'Cavendish' and 'Chandler' were 0.50 %, 0.55 % and 0.63 %, respectively (Fig. 1).

Weight loss in fresh fruits depends on water vapour permeability of package and the relative humidity of storage atmosphere. SANZ et al. (1999) found that among the micro-perforated samples, weight loss was lower for packages with 1.57 mm^2 of perforation surface than that of 4.71 mm^2 in strawberries. These results are in agreement with our data. It can be suggested that perforated plastic boxes prevent weight loss of strawberries during the storage.

Firmness

Initial flesh firmness values of 'Camarosa', 'Cavendish' and 'Chandler' were 0.79 lb, 0.45 lb and 0.54 lb, respectively. Flesh firmness changed significantly during the storage period for all three cultivars. At the end of the storage period flesh firmness of 'Camarosa', 'Cavendish' and 'Chandler' were 1.01 lb, 0.81 lb and 0.65 lb, respectively. Flesh firmness of 'Camarosa' and 'Chandler' increased in the first 5 days of storage and then decreased. In 'Cavendish', this value increased in the first 5 days and remained constant for the rest of the storage time. Thus, strawberry fruits were firmer in cold-air storage (0°C temperature and 90–95 % relative humidity) than at harvest (Fig. 2). This phenomenon is common in strawberries and some stone fruits (HARKER et al. 1997). Likewise, several authors have reported increases in strawberry firmness by low temperature (LARSEN and WATKINS 1995; WATKINS et al. 1999). It was speculated that increases in the firmness of stone fruits were due to a change in the behaviour of the pectin (perhaps increasing viscosity) since pectin structure/chemistry did not change (WERNER and FRENKEL

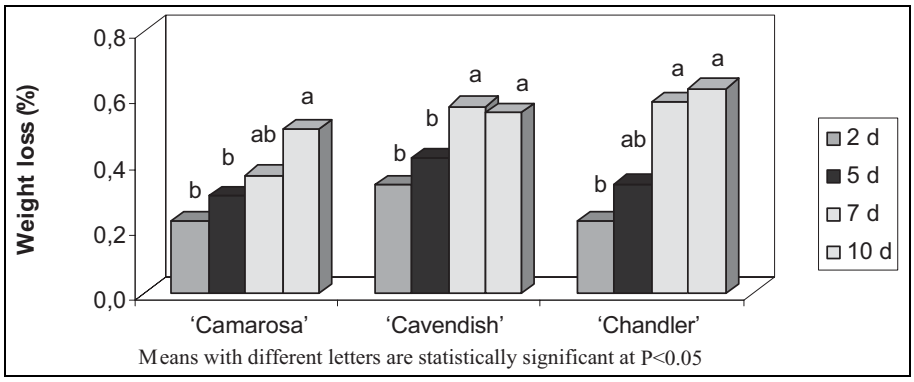


Fig. 1. Weight losses of three strawberry cultivars stored at 0 °C in air.

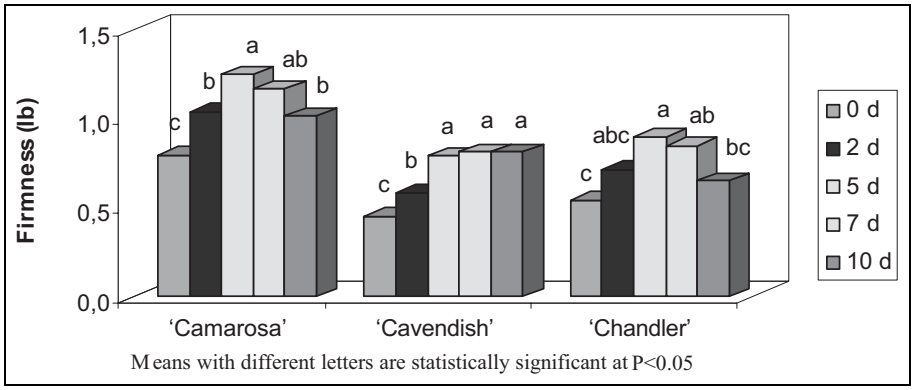


Fig. 2. Firmness changes of three strawberry cultivars stored at 0 °C in air.

1978; WERNER et al. 1978). Other carbohydrates like cellulose and hemicellulose also have important effect on flesh firmness (CEMEROGLU et al. 2001). On the other hand, HARKER et al. (2000) and PELAYO et al. (2002) reported that the mechanism of the cold effect is not well understood.

Changes of total soluble solid, titratable acidity, and pH-value of fruits

Significant variations on total soluble solid contents of strawberries were observed due to the storage duration except for 'Camarosa' (Table 1). While the total soluble solid content of 'Cavendish' decreased, an increase was observed in cultivar 'Chandler'. Before storage, total soluble solid contents of cultivars varied from 5.55 % ('Chandler') to 7.50 % ('Cavendish'). At the end of the storage time, the total soluble solid contents reached values between 6.00 % for 'Chandler' and 6.88 % for 'Camarosa'. Similar results were reported by GARCIA et al. (1998) and PELAYO et al. (2002). While, PELAYO et al. (2002) found an increase in total soluble solid content for one strawberry cultivar, GARCIA et al. (1998) determined a decrease during the storage time.

Initial TA of the 'Camarosa', 'Cavendish' and 'Chandler' were 0.64 %, 0.47 % and 0.63 %, respectively. At the 10th day of the storage 'Camarosa' showed higher values of titratable acidity (0.55 %) compared to the others ('Cavendish': 0.46 %; 'Chandler': 0.54 %). While initial pH values of 'Camarosa', 'Cavendish' and 'Chandler' were 3.56, 3.65 and 3.44, respectively, these values fluctuated without any trend from the initial value to the value at the last storage day and resulted in 3.70, 3.76 and 3.62, respectively. Storage time showed a significant effect on the changes of both TA and pH except for TA content of 'Camarosa'. TA decreases seems to be clearer for 'Chandler' than for 'Cavendish' (Table 1). GARCIA et al. (1998) speculated that acidity decrease demonstrates maturation development. These results agreed with those found by EL GAOUTH et al. (1991), PELAYO et al. (2002) and KOYUNCU and AŞKIN (1999) in strawberries and the other fruits (KARAÇALI 2002).

For an acceptable flavour, a maximum of 0.8 % TA and/or a minimum of 7 % TSS have been recommended (MITCHAM et al. 1996). All strawberry cultivars fitted within the recommended TA value. 'Chandler' does not fulfil these recommendations for TSS, whereas 'Camarosa' achieves it as fresh fruit only and 'Cavendish' up to 7 days of storage time (Table 1).

Colour

Data from colour evaluation by colorimeter are presented in Table 2. Colorimeter values (L*, a*, b*, C* and hº) of strawberries stored 10 days decreased in comparison to initial values in all cultivars. Changes of some colorimeter values of cultivars were statistically significant except for 'Chandler'. Colour values a* and b* were converted into chroma (C*) and hue angle (hº), which give better idea of strawberry colour change along the experiment (HOLCROFT and KADER 1999). The colour of 'Cavendish' fruit became darker (lower L* values), less vivid (lower C* values) and was more red (lower hº values) with increased storage time. Similar trends were observed in 'Camarosa' and 'Chandler' during their postharvest life. Likewise, HOLCROFT and KADER (1999), PEREZ and SANZ (2001) and PELAYO et al. (2002) found that colorimeter values (L*, C* and hº) decreased in strawberries during the storage period. These findings evidently support the results obtained in this research.

Table 1. Changes in TSS, TA and pH of three strawberry cultivars during the storage period.

Cultivars	Storage time (days)	TSS (%)	TA (%)	pH
'Camarosa'	0	7.25 ^{ns}	0,64 ^{ns}	3.56 c
	2	6.75	0,67	3.46 d
	5	6.75	0,59	4.04 a
	7	6.63	0,57	3.45 d
	10	6.88	0,55	3.70 b
'Cavendish'	0	7.50 a	0,47 bc	3.65 c
	2	7.63 a	0,53 a	3.55 d
	5	7.75 a	0,49 b	4.12 a
	7	7.00 b	0,37 d	3.57 d
	10	6.63 b	0,46 c	3.76 b
'Chandler'	0	5.55 b	0,63 a	3.44 c
	2	6.00 a	0,62 a	3.43 c
	5	5.88 a	0,64 a	3.93 a
	7	6.00 a	0,59 a	3.35 d
	10	6.00 a	0,54 b	3.62 b

Means in the same column of each cultivar with different letters are statistically significant at $P<0.05$
ns, not significant

Table 2. Changes in colour of three strawberry cultivars during the storage period.

Cultivars and storage days	Colour				
	L*	a*	b*	C*	h°
'Camarosa'					
0	34.40 ns	40.99 a	27.91 ns	49.59 a	34.25 ns
2	33.50	40.88 a	27.44	49.24 a	33.86
5	33.36	40.01 ab	26.91	48.23 ab	33.91
7	32.91	39.22 b	25.27	46.66 b	32.77
10	34.04	38.88 b	25.61	46.56 b	33.38
'Cavendish'					
0	34.76 a	38.70 ns	28.69 a	48.18 a	36.55 a
2	32.55 b	37.79	25.56 b	45.64 b	34.07 ab
5	31.03 c	36.94	23.69 bc	43.92 bc	32.66 bc
7	30.47 c	36.11	22.63 c	42.62 c	32.08 bc
10	30.98 c	36.12	21.78 c	42.18 c	31.10 c
'Chandler'					
0	37.05 ns	39.18 ns	29.00 ns	48.77 ns	36.44 ns
2	35.88	38.79	30.12	49.14	37.84
5	34.68	37.83	26.99	46.51	35.50
7	35.16	37.10	26.97	45.88	35.99
10	34.62	36.75	25.58	44.79	34.86

Means in the same column of each cultivar with different letters are statistically significant at $P<0.05$
ns, not significant

Sensory evaluations

In this research, we concluded that marketable quality (fungal decay, appearance and texture) and flavour of strawberries were cultivar dependent. While at the 7th day of storage only 'Camarosa' fruits were excellent in terms of marketable quality (7 points), at the end of the storage period 'Cavendish' and 'Chandler' scored higher (6.33 points) than 'Camarosa' (5.67 points). The postharvest life at 0 °C, defined as the maximum storage period with acceptable fruits for marketable quality, was 10 days for all cultivars. Flavour scores of 'Camarosa', 'Cavendish' and 'Chandler' strawberries were 2.67, 3.33 and 3.00 at 10 days of storage period, respectively. 'Cavendish' fruits also scored the highest value (full point on a 5 point scale) at the beginning of storage. The effect of storage time on marketable quality and flavour was statistically significant for all cultivars except for marketable quality of 'Chandler' (Fig. 3, 4).

SANZ et al. (1999), PEREZ et al. (1999), PEREZ and SANZ (2001) and PELAYO et al. (2002) reported that it is possible to storage strawberries at 0–5 °C in air-storage for 7–13 days. In these studies, postharvest life of strawberries was mostly determined by marketable quality of fruits (fungal decay, appearance and texture etc.). PELAYO et al. (2002) also indicated that additional sensory evaluations are needed to confirm results. Our results related to sensory evaluation are in accordance with these reports.

Vitamin C (ascorbic acid)

Fruits are good sources of antioxidants, which may be more effective and economical than supplements in protecting the body against oxidative damage under different conditions (LEONG and SHUI 2002). As an antioxidant content is becoming an increasingly important parameter in fruits and vegetables, it is of great interest to evaluate changes in the antioxidant status during fruit storage (PEREZ and SANZ 2001). Nutritional value of strawberries has been mainly evaluated as the content of ascorbic acid. This acid is quite unstable and thus it is also an indication of fruit freshness (SANZ et al. 1999). Ascorbic acid, better known as vitamin C, is also present in strawberry fruits, giving an added value to this fruit due to its important nutritional implications.

Changes in vitamin C of strawberries during the storage period are shown in Table 3. From the beginning to the end of the storage, vitamin C levels decreased in all cultivars but significant differences were found in 'Camarosa', only. 'Camarosa', 'Cavendish' and 'Chandler' strawberries showed an average content of ascorbic acid of 21.65 mg 100 g^{-1}, 21.55 mg 100 g^{-1}, and 18.55 mg 100 g^{-1}, respectively. The greatest decrease was determined for 'Camarosa' (12.10 mg 100 g^{-1}) at the end of the storage. Similar results were found by PEREZ et al. (1998) in a study related to the storage of strawberries in air (2 °C). On the other hand, PEREZ et al. (1999) and PEREZ and SANZ (2001) found that the

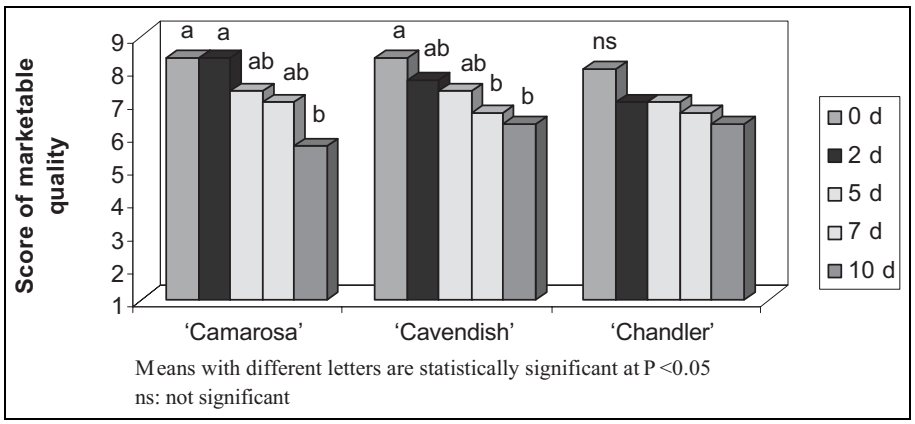


Fig. 3. Changes in marketable quality of three strawberry cultivars stored at 0 °C in air.

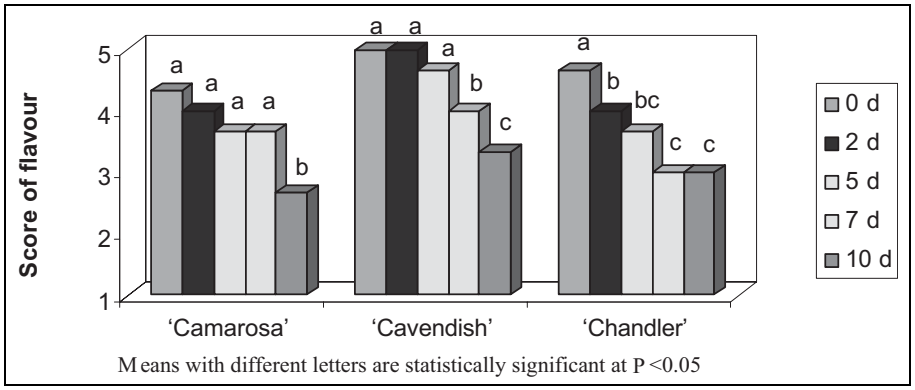


Fig. 4. Flavour changes of three strawberry cultivars stored at 0 °C in air.

vitamin C content of strawberries during the cold storage slightly increased. It can be concluded from these results that the changes of vitamin C content of strawberries during the storage is cultivar dependent.

Organic acids

Citric acid is the most abundant organic acid in strawberry, followed by malic acid (HOLCROFT and KADER 1999). Tartaric, oxalic and fumaric acids were presented in the strawberry fruits in very small amounts; therefore they did not significantly influence the flavour of the fruits (STURM et al. 2003). Changes of organic acids during the storage were found to be statistically significant for all cultivars (Table 3). In these cultivars, citric acid was the dominant organic acid during the storage. Its content for 'Camarosa', 'Cavendish' and 'Chandler' changed from initial values of 4.48 mg g^{-1}, 5.94 mg g^{-1} and 8.60 mg g^{-1}, to 6.09 mg g^{-1} (at the 5th day of storage), 6.82 mg g^{-1} (at the 7th day of storage) and 8.83 mg g^{-1} (at the 2nd day of storage), respectively and then declined. These results agreed with those found by PEREZ et al. (1999), PEREZ and SANZ (2001) and PELAYO et al. (2002).

Malic acid contents of 'Camarosa', 'Cavendish' and 'Chandler' fluctuated during the storage period and no clear trend was visible. Initial values were 3.94 mg g^{-1}, 3.14 mg g^{-1} and 3.19 mg g^{-1} and 3.77 mg g^{-1}, 2.55 mg g^{-1} and 3.11 mg g^{-1} were measured at the 10th day of storage, respectively. The same results were found by PEREZ et al. (1999), PEREZ and SANZ (2001) and PELAYO et al. (2002) at the end of the storage.

Conclusions

The knowledge of the weight loss, flesh firmness, colour, titratable acidity, soluble solid content, vitamin C content and composition of organic acids is important for the evaluation of quality of fruits. These quality attributes of strawberry cultivars 'Camarosa', 'Cavendish' and 'Chandler' changed as a function of storage time. While weight loss and flesh firmness of fruits increased, colorimeter values (L*, a*, b*,C* and h°), titratable acidity and vitamin C contents decreased in comparison to initial values in all cultivars. While citric acid increased, malic acid fluctuated during the storage period. Changes in total soluble solid contents during the storage were cultivar dependent. The total soluble solid contents of 'Cavendish' decreased whereas an increase was observed in cultivar 'Chandler'. It was shown that perforated plastic boxes prevented weight loss of strawberries. Low temperature showed a positive effect on firmness and increased it in comparison to the initial value. Similarly, LARSEN and WATKINS (1995) reported increases in strawberry firmness by low temperature. All strawberry cultivars had the values of TA and TSS for acceptable flavour in the end of the storage. This result was supported by sensory analysis. On the other hand, cold storage has a negative effect on vitamin C content of strawberries. The consumer should take into consideration that the loss of vitamin C can reach a level of 40 % at the end of 10 days storage (Table 3). It can be concluded that the postharvest life at 0 °C, defined as the maximum storage period with acceptable fruits for marketable quality, was 10 days for all cultivars.

Table 3. Changes in vitamin C and organic acids of three strawberry cultivars during the storage period.

Cultivars and Storage days	Vitamin C (mg/g)	Citric acid (mg/g)	Malic acid (mg/g)	Tartaric acid (mg/g)	Oxalic acid (µg/g)	Fumaric acid (µg/g)
'Camarosa'						
0	21.65 a	4.48 c	3.94 c	0.36 b	121.96 d	18.68 a
2	12.50 c	7.39 a	4.91 a	0.52 a	149.39 c	8.83 c
5	13.15 c	6.09 b	3.41 d	0.53 a	100.163e	6.77 d
7	17.30 b	3.68 d	4.38 b	0.53 a	166.83 b	6.80 d
10	12.10 c	3.20 e	3.77 c	0.24 c	252.32 a	9.41 b
'Cavendish'						
0	21.55 ns	5.94 c	3.14 a	0.66 a	87.12 a	6.57 d
2	21.46	5.04 d	0.65 c	0.41 d	42.33 d	5.17 e
5	20.60	8.29 a	3.10 a	0.50 bc	77.51 b	11.94 b
7	19.25	6.82 b	2.59 b	0.48 c	42.83 d	18.77 a
10	17.05	5.07 d	2.55 b	0.51 b	62.49 c	8.77 c
'Chandler'						
0	18.55 ns	8.60 a	3.19 b	0.50 a	95.57 b	11.22 d
2	16.00	8.83 a	3.72 a	0.50 a	65.61 c	15.31 a
5	18.30	6.47 c	3.18 bc	0.44 b	47.64 d	13.19 c
7	18.05	7.25 b	2.81 d	0.45 b	36.13 e	10.14 e
10	17.60	5.91 d	3.11 b	0.51 a	106.92 a	14.80 b

Means in the same column of each cultivar with different letters are statistically significant at $P<0.05$
ns, not significant

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