# Influence of gas mixtures on fruit softening and volatile formation in two plum cultivars (*Prunus domestica* L.)

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*The 36 volatile compounds detected by SPME (solid phase microextraction) in the plum cultivars 'Stanley' and 'Vajlevka' included 1 hydrocarbon, 11 alcohols, 9 aldehydes, 1 ketone, 10 esters and 4 terpenoids. Both cultivars were stored at 1.0 to 1.5 °C and kept in three different experimental atmospheres. One had fluctuating anaerobiosis (FAN), with oxygen concentrations around the limits of aerobic metabolism, with 0.5 to 0.6 % $O_2$ and 0.2 to 0.3 % $CO_2$. There were two controlled atmospheres (CA), the first (CA1) with 0.9 to 1.0 % $O_2$ and 9.0 to 9.2 % $CO_2$, and the second (CA2) with 1.5 to 2.0 % $O_2$ and 14.6 to 15.0 % $CO_2$, plus a regular atmosphere (RA) with 20.9 % $O_2$ and 0.1 % $CO_2$ as a control. Both cultivars showed a maintenance of skin firmness in all three treatments in comparison to a regular atmosphere. Statistical analysis confirmed that the biogenesis of volatiles was very slow at the onset of ripening and developed progressively towards the end of storage in the gas mixtures. Among the nine aldehydes detected, 3-methylbutanal was the predominant compound and the second most common was 3-methyl (Z)-2-butenol, which actually became the dominant compound in the RA treatment by the end of the storage period. Among the 4 terpenoids, limonene was found to be the major compound, although levels decreased during storage. ß-Ionone was consistently higher in 'Vajlevka' compared to 'Stanley', and was affected by the gas mixtures in the controlled atmospheres.*
**Keywords:** plum, storage, controlled atmosphere (CA), low oxygen storage, ethanol, volatiles

***Einfluss der Zusammensetzung der Lageratmosphäre auf das Weichwerden der Früchte und die Bildung flüchtiger Substanzen bei zwei Pflaumensorten*** (Prunus domestica L.)*. Die 36 flüchtigen Substanzen, die mittels SPME (Solid Phase Microextraction) in den Pflaumensorten 'Stanley' und 'Vajlevka' bestimmt wurden, umfassten 1 Kohlenwasserstoff, 11 Alkohole, 9 Aldehyde, 1 Keton, 10 Ester und 4 Terpenoide. Beide Sorten wurden bei 1,0 bis 1,5 °C in drei verschiedenen Lageratmosphären gelagert: FAN (fluktuierende Anaerobiose, mit Sauerstoffkonzentrationen um die Grenzwerte des aeroben Stoffwechsels mit 0,5 bis 0,6 % $O_2$ und 0,2 bis 0,3 % $CO_2$); Kontrollierte Atmosphäre 1 (CA1, mit 0,9 bis 1,0 % $O_2$ und 9,0 bis 9,2 % $CO_2$) und Kontrollierte Atmosphäre 2 (CA2, mit 1,5 bis 2,0 % $O_2$ und 14,6 bis 15,0 % $CO_2$). Als Kontrolle diente eine 'reguläre Atmosphäre' (RA, mit 20,9 % $O_2$ und 0,1 % $CO_2$). Im Vergleich zur Kontrollvariante zeigten beide Sorten in allen drei Lageratmosphären eine Erhaltung der Schalenfestigkeit. Statistische Analysen bestätigten, dass die Bildung flüchtiger Substanzen zu Beginn der Reife sehr gering war und bei fortschreitender Lagerung in den verschiedenen Lageratmosphären zunahm. Unter den neun untersuchten Aldehyden war 3-Methylbutanal die vorherrschende Verbindung, und die zweithäufigste war 3-Methyl-(Z)-2-Butenol, welches bei der RA-Variante am Ende der Lagerung überhaupt die dominante Substanz war. Unter den vier Terpenoiden war Limonen die häufigste Verbindung, obwohl die Gehalte während der Lagerung abnahmen. ß-Jonon war durchgehend häufiger in der Sorte 'Vajlevka' als in 'Stanley' und wurde von der Gaszusammensetzung in den CA-Varianten beeinflusst.*
**Schlagwörter:** Pflaume, Lagerung, Kontrollierte Atmosphäre (CA), Low Oxygen-Lagerung, Ethanol, flüchtige Substanzen

*L'influence de la composition de l'atmosphère de stockage sur l'attendrissement des fruits et la formation de substances volatiles dans deux variétés de prunes* (Prunus domestica **L.**). *Les 36 substances volatiles déterminées par SPME (Solid Phase Microextraction) dans les variétés de prunes 'Stanley' et 'Vajlevka', contenaient 1 hydrocarbure, 11 alcools, 9 aldéhydes, 1 cétone, 10 esters et 4 terpénoïdes. Les deux variétés ont été stockées à une température entre 1,0 et 1,5 °C dans trois atmosphères de stockage différentes : FAN (anaerobiose fluctuante avec des concentrations d'oxygène autour des valeurs limites du métabolisme aérobie, soit de 0,5 à 0,6 % d'O$_2$ et de 0,2 à 0,3 % de CO$_2$) ; atmosphère contrôlée 1 (CA1, de 0,9 à 1,0 % d'O$_2$ et de 9,0 à 9,2 % de CO$_2$) et atmosphère contrôlée 2 (CA2, de1,5 à 2,0 % d'O$_2$ et de 14,6 à 15,0 % de CO$_2$). Une 'atmosphère régulière' (RA, avec 20,9 % d'O$_2$ et 0,1 % de CO$_2$) servait de contrôle. Dans toutes les trois atmosphères de stockage, la fermeté de la peau des deux variétés s'est conservée par rapport à la variante de contrôle. Les analyses statistiques confirment que la formation de substances volatiles était très faible au début de la maturation et qu'elle a augmenté au cours du stockage dans les différentes atmosphères. Parmi les neuf aldéhydes examinés, le 3-méthylbutanal était la liaison prépondérante, suivie par le 3-méthyl-(Z)-2-butanol qui, dans la variante RA, était la substance dominante à la fin du stockage. Parmi les quatre terpénoïdes, le limonène était la liaison le plus fréquente, bien que les teneurs aient baissé au cours du stockage. La ß-ionone était à tout moment plus fréquente dans la variété 'Valjevka' que dans 'Stanley' et était influencée par la composition des gaz dans les variantes CA.*

**Mots clés :** prune, stockage, atmosphère contrôlée (CA), stockage Low Oxygen, éthanol, substances volatiles

Plum fruit can only be stored for a short period in ambient atmospheres due to their fast rate of ripening. However, the characteristics of freshness, such as flavour, texture, colour and overall appearance, can be maintained for a longer period of time by manipulating and slowing down the physiological response to gases such as $O_2$ and $CO_2$ in the ambient atmosphere. For example, elevated $CO_2$ levels retard fruit ripening and these effects are intensified in reduced $O_2$ atmospheres. On the other hand, the complete absence of oxygen, or excessively high levels of $CO_2$, will lead to fermentation and the subsequent accumulation of ethanol and acetaldehyde on fruit tissues. This generally results in a significant decline in fruit quality, even though anaerobic metabolites can sometimes be beneficial for post-harvest fruit quality (PESIS, 2005; SALVADOR et al., 2003). Consequently, several studies have sought to establish where the lower limits of aerobic metabolism lie, and to identify those minimum oxygen concentrations which prevail before the onset of anaerobic conditions (GRAN and BEAUDRY, 1993; PETRACEK et al., 2002; YANEZ et al., 2001; BURDONet al., 2007). In apples stored in an atmosphere containing 8 % $CO_2$ and 1 % $O_2$, there was much more accumulation of ethanol than under an atmosphere of 1 % $O_2$ without any $CO_2$ (GOLIÀS and BÖTTCHER, 2002). Furthermore, CO2 injury can be seen whenever there is a detectable amount of ethanol in fruit tissues (ARGENTA et al., 2002; PINTO et al., 2001). In plums, the effects of post-harvest storage and handling on the biosynthesis of flavour-related volatile compounds are of particular relevance to the final quality of the fruit. The most abundant volatile components are esters, followed by alcohols and aldehydes, ketones, terpenoids and lactones (NUNES et al., 2008; ORTIZ et al., 2010).

This work studied the effects of three different gas mixtures with varying concentrations of $O_2$ and $CO_2$ on the ripening process in two cultivars of plum fruit and the volatile compounds were analysed using SPME methods. The formation of ethanol and other volatile compounds in the juice of intact plums was used to study the physiological response to the different levels of $O_2$ and $CO_2$ in the storage atmosphere.

## Materials and Methods

The picking dates for each cultivar were within the recommended commercial harvesting periods for fruit destined for long-term storage. Two plum fruit cultivars (*Prunus domestica* L., 'Stanley' and 'Valjevka') were harvested in middle of August 2009, 126 and 131 days, respectively, after full bloom, from 8-year old trees grown in an orchard (Agro Stošíkovice, South Moravia). Subsequently fruit were cooled to a temperature of +0.5 to +1.0 °C and the various gas mixtures were introduced in individual containers. In each container the fruit of both cultivars were stored together for a period of 26 days, and then they were stored in a normal oxygen atmosphere (21 % $O_2$ and 0.03 % $CO_2$) for up to 55 days. The storage temperature was

1.0 to 1.5 °C, the relative humidity of the regular atmosphere (RA) variant was 94 to 98 %, and in the hermetically sealed containers it reached 100 %. The controlled atmospheres (CA) were prepared by reducing oxygen levels using activated carbon (Swing-sorb, Besseling, Holland) and by adding $CO_2$ gas from a pressure bottle to achieve the desired values. In the other treatments (FAN and RA) the concentrations of $CO_2$ were kept as low as possible, at around 0.1 %. 40 kg fruit of both cultivars were stored in the following gas mixtures: FAN (fluctuating anaerobiosis; $O_2$ 0.5 to 0.6 % and $CO_2$ 0.2 to 0.3 %); CA1 (controlled atmosphere 1; $O_2$ 0.9 to 1.0 % and $CO_2$ 9.0 to 9.2 %); CA2 (controlled atmosphere 2; $O_2$ 1.5 to 2.0 % and $CO_2$ 14.6 to 15.0 %); RA (regular atmosphere; $O_2$ 20.9 % and $CO_2$ 0.1 %). The concentrations of $O_2$ and $CO_2$ in the gas mixtures were automatically recorded and adjusted three times daily to achieve the required concentrations of $CO_2$ and $O_2$ with an accuracy of 0.1 %.

## Firmness measurement

Skin firmness was measured using a shaped punch, with a diameter of 5 mm, mounted on a multi-purpose texturometer Texan 2000 (made by Mendel University, Brno) interfaced to a personal computer. The penetration rate was 20 mm/min for a distance of 8 mm after contacting the flesh, and the resulting measurements are the means of 20 fruit expressed in MPa.

## Ethanol measurement in the juice of stored fruit

The storage period under different atmospheres (FAN, CA1, CA2) was 41 days, and was followed by storage in air for 61 days. On each sampling date, the juice from 20 individual fruit was divided and homogenized and frozen separately at -27 °C until the analyses were performed. Then the frozen juice from each fruit was thawed and 1 μl of non-diluted and non-filtered sample was injected into a packed chromatography column (length: 1.2 m; diameter: 3 mm) filled with Porapak P (Waters Ass., Inc., Framingham, Mass., USA). The GC settings were: temperature 92 °C; detector temperature 150 °C; injection temperature 120 °C; carrier gas He 12 ml/min, FID. The quantitative measurements of ethanol were carried out with an absolute calibration. The results are expressed in mg/l of juice (GOLIÀS, 2004).

## Measuring volatiles by Solid Phase Micro-Extraction (SPME)

Storage time under different atmospheres was 26 days. In the following period from the 27th to the 61st day the fruit were stored in air. Fresh fruit of the plum cultivars were homogenized and stored at -27 °C until the analyses were performed. Then 2 g of the homogenate were rapidly transferred to a 4 ml sample bottle and kept at 50 °C for 30 minutes. The SPME device for manual use and the 75 μm Carboxen polydimethylsiloxane (CAR/PDMS) fibers were obtained from Supelco (Bellefonte, PA, USA). The fiber was conditioned at 250 °C for 30 min before use. The extraction fiber was then inserted into the headspace of the sample bottle, and extraction was performed while using a magnetic stirrer for 30 min at 50 °C. The extraction fiber was removed from the sample bottle and inserted into the input port of a GC-MS with preset conditions. After desorption for one minute at 250 °C, the extraction fiber was removed and data collection commenced.

GC-MS measurements were made using an Agilent Technologies 7890A, (Inc., Santa Clara, CA 95052, USA) gas chromatograph interfaced to an Agilent GC MSD 5975 quadruple mass spectrometer using the NIST 98 spectra library. Analytes were separated using a DW WAX fused silica capillary column of 30 m × 0.25 mm with a phase thickness of 0.25 μm from J & W Scientific, which was inserted directly into the ion source of the MS. The splitless mode was used. The mass spectrometer was operated in electron impact mode with an electron energy of 70 eV; source temperature 230 °C; quadruple temperature 150 °C; mass range m/z 30 to 450; scan rate 3.62 s/scan; and EM voltage 1,150. Compounds were provisionally identified using the NIST mass spectra library search, and the identity of most of these compounds was confirmed by comparing their mass spectra and retention times with those obtained for standards (AUBERT et al., 2003).

## Statistical analysis

Statistical analysis was carried out using the statistical package SAS version 9.2 for Windows. At each time point, three samples of two plum varieties in four treatments were analyzed and presented with means and their standard errors.

Analysis of variance (ANOVA) and multiple analysis

of variance (MANOVA) were chosen to analyze the differences in the chemical compounds found in fruit of the two plum varieties held in four different atmospheres. Two plum varieties, four storage atmospheres and different durations of exposure, plus their interactions, were regarded as being potential sources of variation. A fixed effects model was used, and α = 5 % (type I error) was used for the tests of significance. The means of the least significant differences (LSD) between treatments, with 95 % confidence intervals at each time point, are presented in Figures 8 and 9.
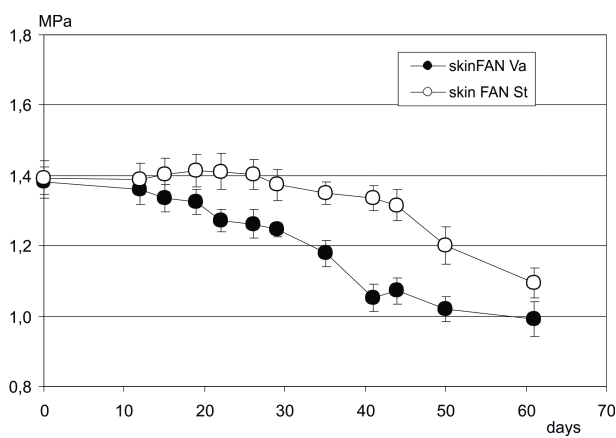


Fig. 1: Changes over time in skin firmness of cvs. 'Stanley' and 'Valjevka' in FAN (fluctuating anaerobiosis, 0.5 to 0.6 % O2 and 0.1 to 0.2 % CO2). Each point is the mean of 12 repetitions. Vertical bars indicate standard errors.
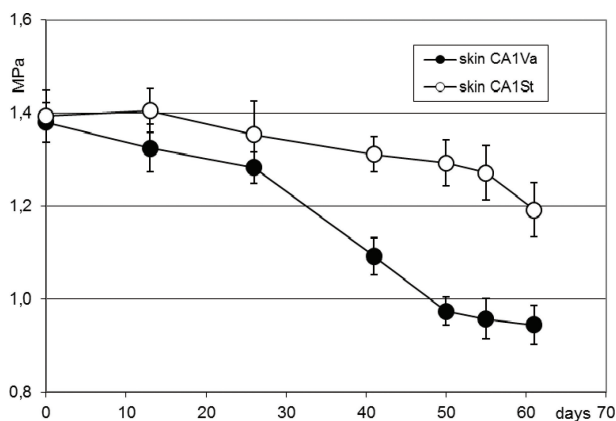


Fig. 2: Changes over time in skin firmness of cvs. 'Stanley' and 'Valjevka' in CA1 (controlled atmosphere 1, O2 0.9 to 1.0 % + CO2 9.0 to 9.2 %). The other values are identical as in Figure 1.
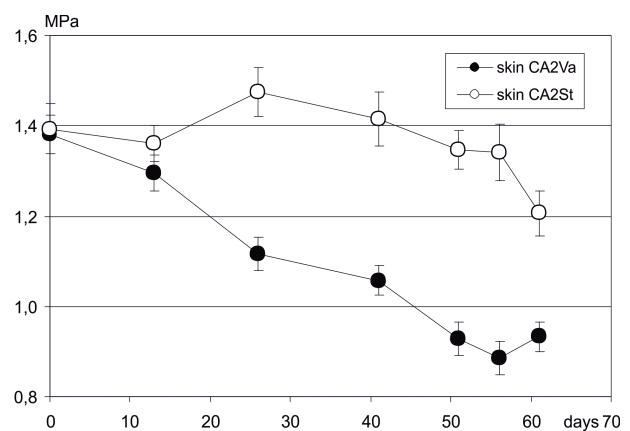


Fig. 3: Changes over time in skin firmness of cvs. 'Stanley' and 'Valjevka' in CA2 (controlled atmosphere 2, O2 1.5 to 2.0 % + CO2 14.6 to 15.0 %). The other values are identical as in Figure 1.
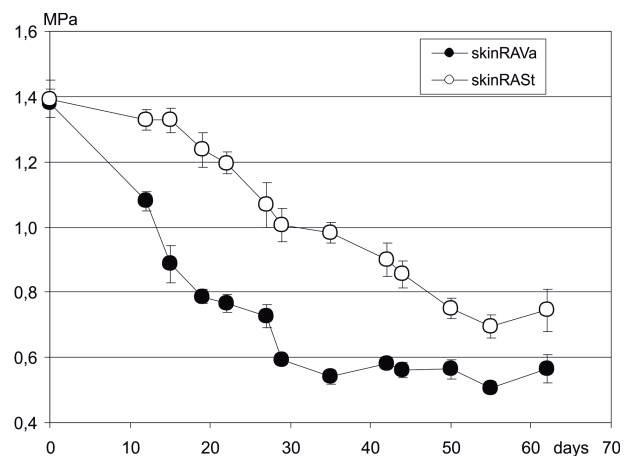


Fig. 4: Changes over time in skin firmness of cvs. 'Stanley' and 'Valjevka' in RA (regular atmosphere, O2  20.9 % + CO2 0.1 %). The other values are identical as in Figure 1.

## Results

### Fruit Softening in the two cultivars

Skin firmness is one of the best indicators of ripening and is also commonly used as a predictor of shelf life. Initial values for skin firmness of plums were 1.39 ± 0.06 and 1.38 ± 0.04 for the cultivars 'Stanley' and
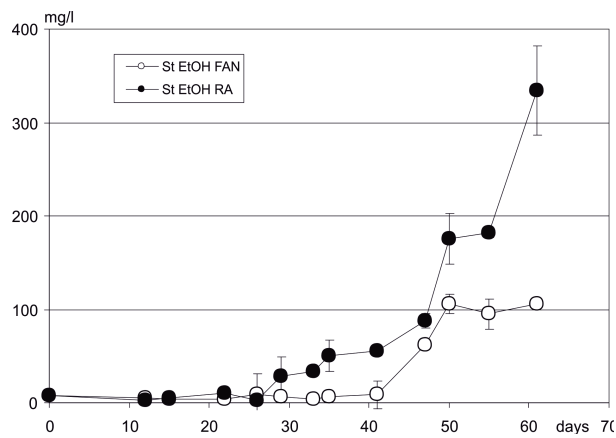
Fig. 5: Changes over time of ethanol in pulp of 'Stanley' plums stored in FAN (fluctuating anaerobiosis) and RA (regular atmosphere). Each point is the mean of 5 repetitions. Vertical bars indicate standard errors.
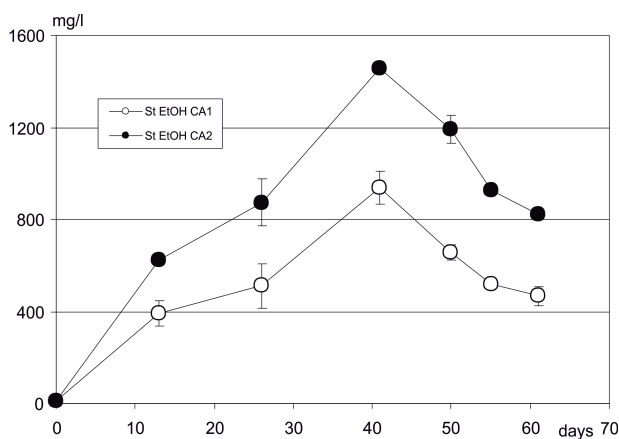


Fig. 6: Ethanol concentration (mg/l) in fruit of cv. 'Stanley' in CA1 (controlled atmosphere 1, O2 0.9 to 1.0 % and CO2 9.0 to 9.2 % ) and CA2 (controlled atmosphere 2, O2 1.5 to 2.0 % + CO2 14.6 to 15.0 %). The other values are identical as in figure 5.



Fig. 7: Effect of CO2 and O2 levels on ethanol content (mg/l) in pulp of cv. 'Stanley' and 'Vajlevka' in FAN (fluctuating anaerobiosis, 0.5 to 0.6 % O2 + 0.1 to 0.2 % CO2), RA (regular atmosphere, 20.8 to 20.9 % O2 + 0.1 to 0.2 % CO2), CA1 (controlled atmosphere 1, O2 0.9 to 1.0 % and CO2 9.0 to 9.2 %) and CA2 (controlled atmosphere 2, O2 1.5 to 2.0 % and CO2 14.6 to 15.0 %) at +0.5 to +1.0 °C for 41 and 61 days. The other values are identical as in figure 5.

atmospheres with higher levels of $CO_2$ has the greater potential for maintaining firmness. The low $O_2$ levels in the FAN atmosphere limit the softening and make 30 days the effective storage period, as after that time a faster softening manifested (Fig. 1). The softening observed in the cv. 'Vajlevka' was higher than in the cv. 'Stanley' in all atmospheres. Skin firmness in fruit stored in air (RA) continuously decreased to a final value of 0.53 MPa, which represents very soft, totally flaccid fruit.

## Levels of ethanol in different gas mixture atmospheres

Ethanol levels in the juice from plum fruit at the onset of storage were 8.32 ± 2.58 mg/l for the cv. 'Stanley' (Fig. 3), and 3.50 ± 0.51 mg/l for the cv. 'Valjevka'. Ethanol levels in the FAN treatments remained unchanged throughout the storage period in the gas mixture, and the values were the same as those in the RA treatment (Fig. 5). Only with the onset of sene-

'Vajlevka', respectively. Both cultivars stored at 1.0 to 1.5 °C in each of the three experimental atmospheres showed a significant maintenance of firmness compared to the fruit stored in air (RA) (Fig. 4). The high $CO_2$ levels in treatment CA2 maintained firmness completely in the cv. 'Stanley', compared to the initial values (Fig. 3), and the results are similar to those in CA1 (Fig. 2). In general, however, fruit stored in
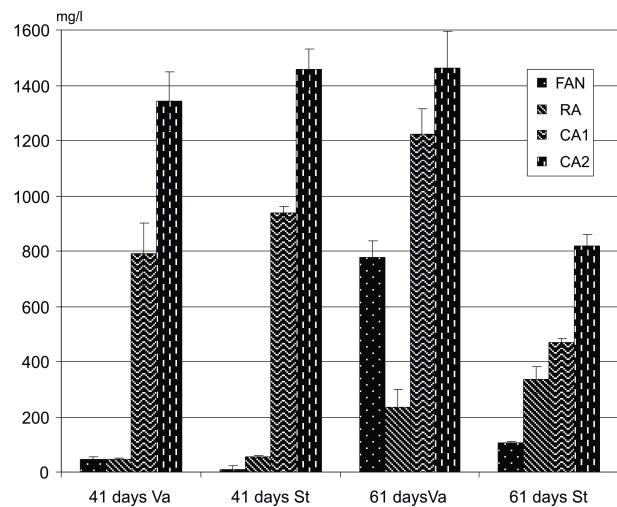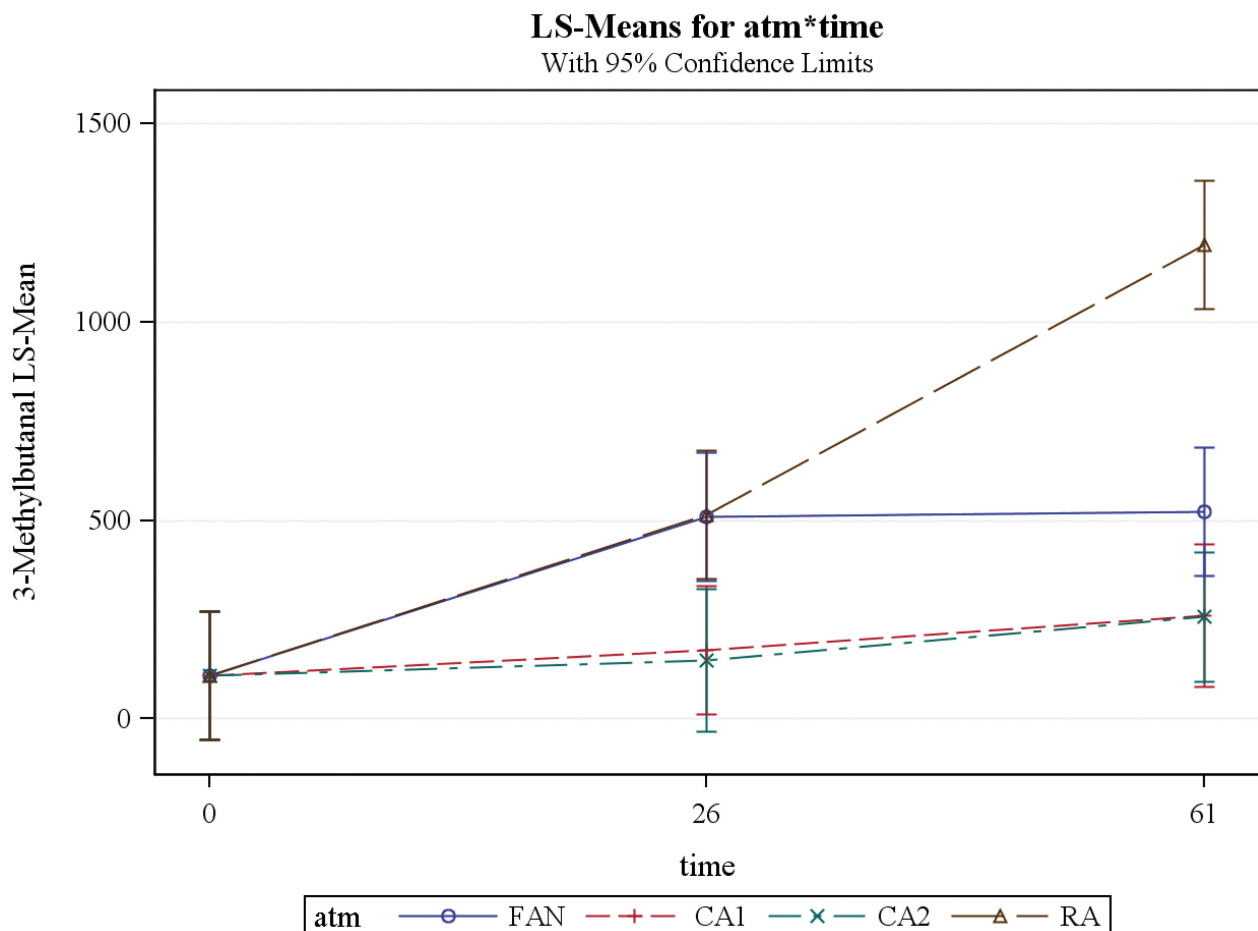
## LS-Means for atm*time
### With 95% Confidence Limits



Fig. 8: LS means score for 3-methylbutanal with 95 % confidence limits for all treatments during storage time.

scence, as indicated by the softening of the fruit and a reduced uptake of oxygen, did values steadily begin to increase, after which a four-fold increase in ethanol was observed. During 41 days of storage in a $CO_2$ rich atmosphere (Fig. 6), ethanol steadily accumulated to reach a concentration of 939 ± 72.5 mg/l and 1457 ± 19.6 mg/l in the CA1 and CA2 atmospheres, respectively. In the following aerobic phase, the accumulated ethanol was not completely metabolized when the fruit were again exposed to RA. Residual concentrations of ethanol were 467 ± 42.3 mg/l (CA1) and 820 ± 21.5 mg/l (CA2) as much as 61 days later (Fig. 7). The long-term effects of higher $CO_2$ concentrations are the same as for very low oxygen levels, namely, the significant production of ethanol and its accumulation in the tissues (Fig. 6). The results pointed out to a high capacity for ethanol production in the cv. 'Valjevka' in

all atmospheres, as well as a noticeably slower ethanol oxidation metabolism after an aeration phase. Ethanol was the most prevalent compound detected in all treatments of cv. 'Stanley' and 'Valjevka'. The increased production is directly related to either the lack of $O_2$ or too much $CO_2$ in the ambient atmospheres experienced during storage (Fig. 6 and 7; Table 1a-1d). Knowing the lower oxygen limit for effective aerobic metabolism is critical for managing the composition of the gaseous atmosphere (BEAUDRY, 1999; GOLIÀS, 2004; PESIS, 2005). Concentrations of ethanol were the highest in CA2, and the next highest were seen in CA1. However, the levels of other alcohols in all the storage atmospheres were little changed, although they were always higher in 'Valjevka' fruit.

## Volatile concentration by SPME methods

A total of 36 volatile compounds, including 1 hydrocarbon, 11 alcohols, 9 aldehydes, 1 ketone, 10 esters

## LS-Means for atm*time
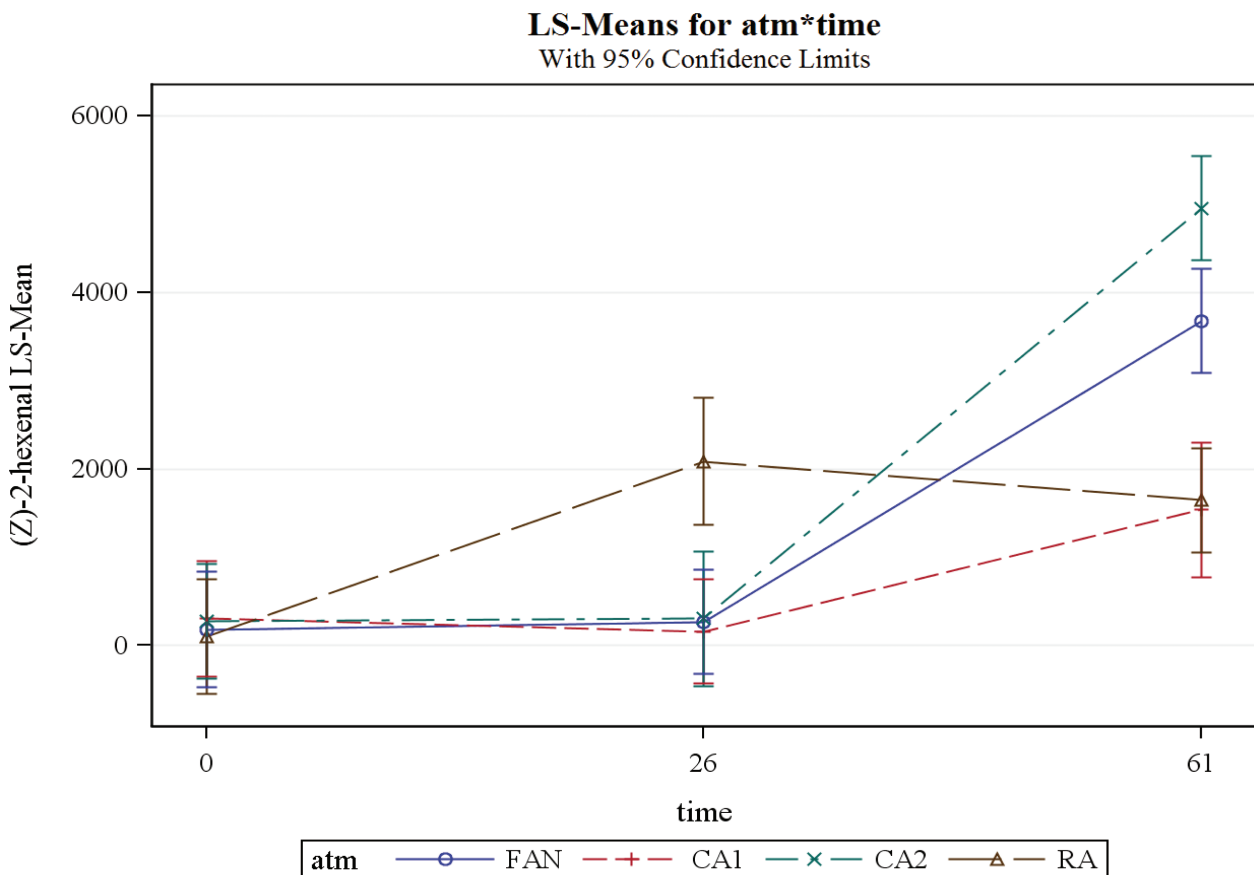### With 95% Confidence Limits



Fig. 9: LS means score for trans-2 hexenal with 95 % confidence limits for all treatments during storage time.

and 4 terpenoids were found in the two cultivars (Table 1a-1d). Five C6 compounds, 1-hexanol, (Z)-2-hexenol, 2-ethylhexanol, n-hexanal and (Z)-2-hexenal, were found in both cultivars. (Z)-2-hexenol and (Z)-2-hexenal were the most prominent volatiles among the $C_6$ compounds. All the $C_6$ compounds were present at the beginning of ripening (Table 1a-1d). (Z)-2-hexenal is derived from the lipoxygenase and hydroperoxide lyase pathway (Gray et al., 1999; Myung et al., 2006) and the high levels of $C_6$ compounds found here were probably due to the breakdown of fatty acids.

Ethanol was the most prevalent compound detected in all treatments of cv. 'Stanley' and 'Valjevka'. The increased production is directly related to either the lack of $O_2$ or too much $CO_2$ in the ambient atmospheres experienced during storage (Fig. 5 to 7; Table 1a-1d). Concentrations of ethanol were the highest in CA2, and the next highest were seen in CA1.

However, the levels of other alcohols in all the storage atmospheres were changed little, being always higher in 'Valjevka' fruit.

Nine aldehydes were detected, with 3-methylbutanal being the dominant one, with levels ranging from 113.2 ± 31.5 µg/kg to 1905 ± 219 µg/kg, and from 103.7 ± 14.2 µg/kg to 486.1 ± 61.8 µg/kg, for the cultivars 'Stanley' and 'Valjevka' respectively. The second most abundant aldehyde was 3-methyl-(Z)-2-butenol, and in the RA treatment it actually became the dominant aldehyde by the end of the storage period. The other aldehydes (n-octanal, n-nonanal, n-decanal, (Z)-2-decenal, 2-furfural) were present in concentrations of less than 20 µg/kg. Pentyl butyrate and butyl-2-methylbutyrate were predominant in the cv. 'Valjevka'. Esters such as (Z)-3-hexenyl acetate and butyl acetate were present at moderate levels during the whole of the controlled atmosphere phase, and then exhibited a sharp decrease when stored for up to 61

## LS-Means for variety*time
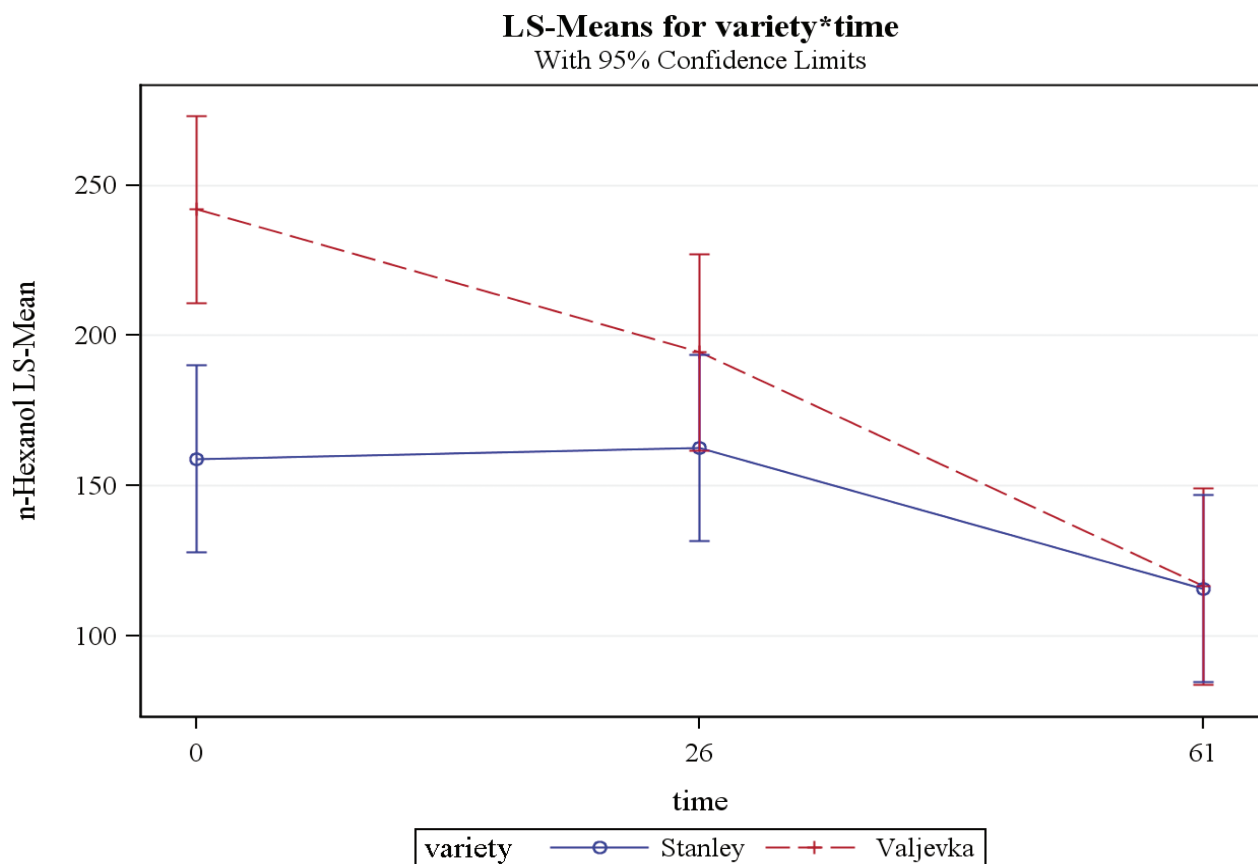### With 95% Confidence Limits



Fig. 10: LS means score for n-hexanol with 95 % confidence limits for cvs. 'Stanley' and 'Valjevka' in all treatments.

days in air. Of the 4 terpenoids found, limonene was the major compound, and levels decreased during storage. $\beta$-Ionone was constantly higher in the cv. 'Valjevka' than in the cv. 'Stanley', and it was not greatly influenced by the different gas mixtures.

### Statistical significance of the formation of volatiles recorded by SPME

The effects of the experimental atmospheres on volatiles of 3-methylbutanal and trans-2-hexenal are illustrated in Figures 8 and 9. The biogenesis of volatiles at the onset of ripening was very slow in all experimental atmospheres and progressively developed after the fruit were removed from storage in the gas mixtures. The biosynthesis of 3-methylbutanal essentially ceased when the fruit were exposed to high $CO_2$ atmospheres (Fig. 8). Significant differences in the levels of selected volatiles were recorded for the cv. 'Stanley' compared to the cv. 'Valjevka', comparing treatments and duration of storage (Fig. 10). Table 2 presents the probabilities of the significance tests on the effects of the various factors (plum varieties, storage atmospheres and storage time) and their interactions in an analysis of variance for all selected volatiles. Significant effect treatment and time were observed for ethanol, 2-methylbutan-1-ol, 3-methylbutanal, n-hexan-1-ol, 2-methyl pentan-1-ol and 2-methylbutanal.

## Discussion

### Effect of atmosphere on ethanol formation and fruit softening

Softening is an important factor in the ripening process of plums that can cause a significant reduction in

Table 1a: Volatile compounds determined by SPME (µg/kg) for treatments and duration of storage (Cv.: S = Stanley, V = Valjevka)
*(continuing opposite and the following two pages)*

| Compounds | Cv. | IN 0 days | FAN 26 days | FAN 61 days | CA1 26 days | CA1 61 days |
|---|---|---|---|---|---|---|
| Ethanol | S | 111.8 ± 3.9 | 1127 ± 704 | 1554 ± 350 | 15246 ± 828 | 7543 ± 1283 |
| | V | 155.9 ± 14.3 | 3376 ± 941 | 14320 ± 1301 | 11262 ± 992 | 22415 ± 550 |
| n-Pentan-1-ol | S | 6.89 ± 0.62 | 7.12 ± 1.93 | 4.48 ± 0.80 | 6.57 ± 0.31 | 4.23 ± 0.65 |
| | V | 9.37 ± 0.44 | 14.42 ± 0.37 | 5.96 ± 0.34 | 6.34 ± 0.67 | 8.90 ± 1.09 |
| 2-Methylbutan-1-ol | S | 2015 ± 86 | 2563 ± 231 | 1139 ± 252 | 2553 ± 439 | 1032 ± 127 |
| | V | 2783 ± 63 | 4255 ± 886 | 1897 ± 224 | 2560 ± 519 | 2066 ± 221 |
| 3-Methylbutanal | S | 113.2 ± 31.5 | 444.6 ± 85.3 | 546.1 ± 137.4 | 169.3 ± 5.3 | 165.3 ± 19.9 |
| | V | 103.7 ± 14.2 | 571.8 ± 48.7 | 496.8 ± 9.2 | 178.9 ± 23.7 | 444.0 ± 35.9 |
| 3-Methyl pentan-1-ol | S | 116.6 ± 33.8 | 63.73 ± 8.89 | 51.61 ± 1.08 | 64.12 ± 8.09 | 42.33 ± 16.73 |
| | V | 147.9 ± 33.0 | 76.38 ± 28.96 | 49.29 ± 2.29 | 66.48 ± 6.45 | 64.61 ± 7.56 |
| 4-Methyl pentan-1-ol | S | 121.8 ± 26.0 | 127.3 ± 51.7 | 122.1 ± 16.8 | 96.78 ± 9.68 | 122.1 ± 30.6 |
| | V | 339.1 ± 35.4 | 141.0 ± 39.6 | 211.4 ± 19.6 | 127.2 ± 17.4 | 461.5 ± 44.0 |
| n-Hexan-1-ol | S | 158.9 ± 28.0 | 184.8 ± 17.8 | 208.9 ± 35.4 | 109.7 ± 17.6 | 87.71 ± 3.91 |
| | V | 242.0 ± 40.5 | 180.2 ± 15.7 | 101.3 ± 6.8 | 96.63 ± 18.24 | 70.29 ± 19.60 |
| Phenol | S | 11.18 ± 0.46 | 14.58 ± 0.36 | 17.28 ± 1.75 | 14.18 ± 2.09 | 11.17 ± 2.30 |
| | V | 16.37 ± 1.48 | 28.23 ± 3.14 | 17.09 ± 2.04 | 18.99 ± 3.05 | 17.50 ± 0.89 |
| 3-Methyl (Z)-2-butenol | S | 303.1 ± 27.8 | 325.6 ± 14.6 | 244.6 ± 28.5 | 209.8 ± 8.5 | 165.0 ± 5.1 |
| | V | 646.3 ± 82.8 | 518.8 ± 40.9 | 271.0 ± 33.7 | 195.2 ± 25.6 | 263.2 ± 30.6 |
| (Z)-2-Hexenol | S | 1567 ± 182 | 1181 ± 244 | 1954 ± 765 | 1086 ± 258 | 1401 ± 436 |
| | V | 2450 ± 83 | 784.5 ± 131.0 | 150.8 ± 4.8 | 77.88 ± 21.94 | 558.8 ± 159.5 |
| 2-Methyl pentan-1-ol | S | 105.1 ± 40.1 | 7012 ± 603 | 200.8 ± 30.7 | 100.4 ± 32.8 | 81.53 ± 7.53 |
| | V | 147.0 ± 59.1 | 2065 ± 324 | 231.4 ± 16.2 | 544.9 ± 50.6 | 254.4 ± 4.7 |
| Ethylhexan-1-ol | S | 6.23 ± 1.07 | 7.00 ± 0.69 | 12.65 ± 3.94 | 9.03 ± 1.21 | 4.62 ± 0.60 |
| | V | 6.99 ± 0.18 | 5.77 ± 0.83 | 11.40 ± 6.13 | 5.79 ± 0.82 | 12.83 ± 1.33 |
| 2-Methylbutanal | S | 55.24 ± 14.66 | 215.2 ± 41.8 | 206.3 ± 18.3 | 101.7 ± 6.4 | 62.04 ± 13.95 |
| | V | 52.93 ± 5.90 | 316.0 ± 22.7 | 231.6 ± 35.0 | 128.9 ± 12.2 | 200.2 ± 51.7 |
| n-Decanal | S | 0.55 ± 0.12 | 1.00 ± 0.00 | 0.55 ± 0.04 | 0.91 ± 0.01 | 0.62 ± 0.02 |
| | V | 0.67 ± 0.19 | 0.49 ± 0.09 | 0.72 ± 0.06 | 0.56 ± 0.06 | 0.78 ± 0.05 |
| 2-Furfural | S | 18.49 ± 11.99 | 15.78 ± 3.47 | 19.14 ± 5.64 | 13.79 ± 2.58 | 42.19 ± 16.26 |
| | V | 17.91 ± 8.64 | 30.32 ± 7.65 | 40.31 ± 10.28 | 16.41 ± 3.61 | 44.34 ± 0.88 |
| (Z)-2-Decenal | S | 0.62 ± 0.12 | 0.43 ± 0.09 | 0.60 ± 0.09 | 0.77 ± 0.00 | 0.48 ± 0.00 |
| | V | 0.32 ± 0.07 | - | - | 0.90 ± 0.00 | 0.54 ± 0.00 |
| n-Nonanal | S | 1.70 ± 0.23 | 1.31 ± 0.26 | 3.49 ± 2.50 | 3.27 ± 2.49 | 1.10 ± 0.25 |
| | V | 2.93 ± 1.32 | 13.15 ± 3.35 | 1.21 ± 0.05 | 7.64 ± 0.88 | 1.93 ± 0.46 |
| n-Octanal | S | 14.06 ± 3.10 | 9.78 ± 3.94 | 14.62 ± 2.82 | 15.78 ± 2.78 | 6.55 ± 1.47 |
| | V | 21.06 ± 2.87 | 50.18 ± 12.99 | 16.23 ± 3.47 | 34.83 ± 3.41 | 18.60 ± 9.66 |
| n-Hexanal | S | 88.87 ± 9.07 | 42.84 ± 1.50 | 27.33 ± 0.00 | 46.94 ± 19.02 | 15.59 ± 0.00 |
| | V | 32.33 ± 13.75 | 62.78 ± 12.10 | 13.71 ± 2.07 | 35.00 ± 1.33 | 22.91 ± 2.38 |
| (Z)-2-Hexenal | S | 227.3 ± 22.4 | 135.1 ± 15.9 | 2932 ± 625 | 124.5 ± 10.6 | 2370 ± 371 |
| | V | 204.7 ± 98.6 | 402.3 ± 101.7 | 4422 ± 460 | 191.2 ± 8.8 | 45.62 ± 0.00 |
| Acetophenone | S | 3.34 ± 0.10 | 3.47 ± 0.70 | 4.36 ± 0.45 | 4.11 ± 0.74 | 4.61 ± 0.30 |
| | V | 4.06 ± 1.19 | 3.24 ± 0.38 | 4.94 ± 0.36 | 3.08 ± 0.26 | 8.62 ± 0.79 |
| Ethyl acetate | S | 0.51 ± 0.45 | 6.28 ± 0.14 | 3.18 ± 2.37 | 4.85 ± 0.00 | 0.43 ± 0.00 |
| | V | 0.92 ± 0.12 | 7.71 ± 0.40 | 3.37 ± 0.69 | 5.68 ± 0.00 | - |
| 2-Methylbutyl acetate | S | 528.1 ± 41.8 | 539.7 ± 132.9 | 57.95 ± 23.37 | 438.8 ± 169.6 | 58.52 ± 34.77 |
| | V | 336.5 ± 104.8 | 650.3 ± 178.7 | 64.51 ± 5.83 | 158.8 ± 23.3 | 111.8 ± 35.4 |
| (Z)-2-Hexenyl acetate | S | 73.19 ± 35.75 | 96.23 ± 43.83 | - | 116.7 ± 49.1 | - |
| | V | 57.33 ± 3.21 | 24.96 ± 6.34 | - | - | - |
| Pentyl butyrate | S | 1351 ± 0 | 132.8 ± 0.0 | 1247 ± 100 | 4.97 ± 0.00 | 1102 ± 6 |
| | V | 1029 ± 361 | 773.2 ± 58.2 | 1351 ± 117 | 1068 ± 12 | 1691 ± 11 |
| Ethyl (Z)- 3-hexenoate | S | 62.14 ± 6.15 | 50.99 ± 18.02 | 45.87 ± 5.16 | 52.27 ± 20.46 | 68.03 ± 4.31 |
| | V | 77.71 ± 40.13 | 59.37 ± 21.40 | 86.16 ± 12.36 | 55.17 ± 11.87 | 209.7 ± 19.1 |
| Methyl (Z)-2-octenoate | S | 0.28 ± 0.00 | 0.26 ± 0.01 | 0.23 ± 0.01 | 0.31 ± 0.00 | - |
| | V | 0.37 ± 0.02 | 0.37 ± 0.04 | 0.50 ± 0.01 | 0.38 ± 0.07 | 0.88 ± 0.06 |

quality during post-harvest life (CRISOSTO et al., 2004; VALERO et al., 2007).

In our study, firmness slowly decreased while the fruit was kept in the gas mixtures in cold storage. When the fruit were transferred to shelf life conditions (RA), the softening process from CA1 and CA2 recorded with the cultivar 'Stanley', was accelerated and appears to exceed a certain natural limit. However, exposing fruit to higher levels of $CO_2$, as in CA1 and of CA2, resulting in increase in anaerobic respiration and the paral-lel accumulation of ethanol (800 to 1200 mg/l), did not cause an off-flavour identifiable at sensory evaluation. In addition, it stops the softening of fruit (as measured by skin firmness). The higher concentrations of $CO_2$ in ambient atmosphere CA2 were more effective in inhibiting softening than in CA1. The mean alcohol levels in the plums increased during their shelf life storage period, with the exception of ethanol, regardless of the earlier storage regime, and especially large increases in the levels of (Z)-2-hexenol

Table 1b: Volatile compounds determined by SPME (μg/kg) for treatments and duration of storage
*(cont.)*

| Compounds | Cv. | CA2 | | RA | |
|---|---|---|---|---|---|
| | | 26 days | 61 days | 26 days | 61 days |
| Ethanol | S | 28215 ± 149 | 15151 ± 1721 | 114.9 ± 13.8 | 6671 ± 342 |
| | V | 18173 ± 1131 | 23951 ± 3089 | 439.6 ± 114.6 | 8670 ± 2467 |
| n-Pentan-1-ol | S | 5.28 ± 1.11 | 6.18 ± 0.95 | 6.32 ± 0.75 | 7.83 ± 0.79 |
| | V | 6.11 ± 0.99 | 8.39 ± 2.19 | 15.96 ± 1.97 | 8.49 ± 1.16 |
| 2-Methylbutan-1-ol | S | 2081 ± 156 | 2274 ± 188 | 1334 ± 307 | 551.3 ± 27.8 |
| | V | 2603 ± 800 | 1849 ± 212 | 1885 ± 470 | 845.2 ± 267.5 |
| 3-Methylbutanal | S | 149.9 ± 5.4 | 321.4 ± 54.5 | 605.6 ± 9.1 | 1905 ± 219 |
| | V | 128.3 ± 29.4 | 191.6 ± 40.7 | 421.9 ± 88.7 | 486.1 ± 61.8 |
| 3-Methyl pentan-1-ol | S | 104.6 ± 31.8 | 96.26 ± 10.29 | 69.19 ± 3.32 | 45.11 ± 3.29 |
| | V | 53.40 ± 5.82 | 40.44 ± 11.28 | 74.13 ± 5.13 | 52.64 ± 14.48 |
| 4-Methyl pentan-1-ol | S | 131.7 ± 3.6 | 224.0 ± 24.4 | 88.85 ± 26.73 | 186.8 ± 3.3 |
| | V | 153.5 ± 73.0 | 403.2 ± 5.3 | 256.5 ± 100.2 | 434.7 ± 29.9 |
| n-Hexan-1-ol | S | 72.48 ± 9.80 | 94.81 ± 19.71 | 283.5 ± 43.7 | 71.61 ± 16.23 |
| | V | 76.46 ± 1.00 | 63.70 ± 19.66 | 422.6 ± 52.1 | 231.3 ± 40.6 |
| Phenol | S | 14.31 ± 0.16 | 21.82 ± 2.42 | 21.61 ± 9.03 | 17.90 ± 1.40 |
| | V | 21.53 ± 4.49 | 16.86 ± 1.47 | 29.15 ± 5.23 | 16.79 ± 1.52 |
| 3-Methyl (Z)-2-butenol | S | 217.0 ± 17.7 | 251.2 ± 41.1 | 273.3 ± 23.5 | 118.3 ± 13.1 |
| | V | 131.5 ± 9.8 | 266.8 ± 54.6 | 411.7 ± 100.3 | 137.7 ± 20.5 |
| (Z)-2-Hexenol | S | 1861 ± 82 | 3005 ± 266 | 1212 ± 223 | 2091 ± 423 |
| | V | 146.6 ± 30.7 | 2076 ± 530 | 1032 ± 239 | 65.39 ± 22.49 |
| 2-Methyl pentan-1-ol | S | 97.14 ± 30.49 | 277.1 ± 56.7 | 60.23 ± 11.60 | 228.5 ± 101.9 |
| | V | 326.9 ± 0.0 | 256.2 ± 60.1 | 1197 ± 307 | 289.3 ± 75.4 |
| Ethylhexan-1-ol | S | 7.91 ± 0.74 | 12.19 ± 2.79 | 6.44 ± 0.57 | 11.50 ± 3.78 |
| | V | 8.30 ± 2.95 | 15.23 ± 1.51 | 15.14 ± 4.56 | 9.73 ± 2.68 |
| 2-Methylbutanal | S | 86.76 ± 1.77 | 134.1 ± 38.2 | 245.8 ± 31.2 | 535.1 ± 81.0 |
| | V | 90.78 ± 17.26 | 118.5 ± 25.8 | 197.1 ± 12.0 | 303.0 ± 43.2 |
| n-Decanal | S | 0.75 ± 0.19 | 0.69 ± 0.04 | 0.91 ± 0.13 | 0.55 ± 0.04 |
| | V | 0.72 ± 0.02 | 0.64 ± 0.07 | 0.74 ± 0.09 | 0.85 ± 0.08 |
| 2-Furfural | S | 30.19 ± 0.91 | 22.03 ± 3.78 | 15.03 ± 7.56 | 25.89 ± 9.01 |
| | V | 12.11 ± 3.13 | 31.46 ± 16.89 | 19.88 ± 0.00 | 60.06 ± 10.90 |
| (Z)-2-Decenal | S | 0.41 ± 0.07 | 1.79 ± 0.87 | 0.35 ± 0.05 | 3.18 ± 2.55 |
| | V | 4.01 ± 0.00 | - | 0.62 ± 0.23 | 1.13   0.00 |
| n-Nonanal | S | 0.91 ± 0.19 | 1.91 ± 0.18 | 3.46 ± 0.95 | 3.34 ± 0.68 |
| | V | 1.30 ± 0.04 | 3.02 ± 0.96 | 9.84 ± 6.16 | 1.66 ± 0.03 |
| n-Octanal | S | 22.72 ± 2.80 | 12.92 ± 1.94 | 14.70 ± 2.64 | 11.41 ± 1.76 |
| | V | 17.84 ± 5.54 | 15.70 ± 5.82 | 65.67 ± 22.65 | 7.08 ± 3.01 |
| n-Hexanal | S | 90.81 ± 28.68 | 25.91 ± 2.39 | 49.42 ± 26.08 | 25.50 ± 5.13 |
| | V | 77.61 ± 33.24 | 26.58 ± 0.98 | 64.20 ± 18.22 | 20.12 ± 4.17 |
| (Z)-2-Hexenal | S | 263.0 ± 18.9 | 5428 ± 322 | 49.19 ± 13.47 | 1355 ± 115 |
| | V | 77.31 ± 0.00 | 4478 ± 571 | 4121 ± 141 | 1934 ± 615 |
| Acetophenone | S | 4.93 ± 0.26 | 5.94 ± 0.39 | 6.04 ± 1.69 | 6.83 ± 0.53 |
| | V | 3.69 ± 1.23 | 6.37 ± 0.95 | 5.72 ± 1.94 | 7.70 ± 0.74 |
| Ethyl acetate | S | - | 4.10 ± 0.83 | 3.86 ± 0.56 | 1.96 ± 1.47 |
| | V | - | - | 3.19 ± 0.82 | - |
| 2-Methylbutyl acetate | S | 510.6 ± 112.0 | 82.30 ± 3.25 | 103.1 ± 4.8 | 91.76 ± 18.89 |
| | V | 114.5 ± 58.4 | 94.07 ± 13.33 | 202.9 ± 135.9 | 87.40 ± 7.59 |
| (Z)-2-Hexenyl acetate | S | 135.3 ± 41.7 | - | 101.1 ± 64.3 | - |
| | V | - | - | 84.95 ± 0.00 | - |
| Pentyl butyrate | S | 170.0 ± 161.6 | 1324 ± 104 | 1284 ± 0 | 1173 ± 206 |
| | V | 1151 ± 178 | 1378 ± 117 | 1314 ± 32 | 10643 ± 55 |
| Ethyl (Z)- 3-hexenoate | S | 54.99 ± 7.38 | 84.58 ± 9.08 | 51.48 ± 8.97 | 79.00 ± 6.87 |
| | V | 72.08 ± 31.20 | 176.3 ± 10.6 | 115.3 ± 28.7 | 187.1 ± 11.2 |
| Methyl (Z)-2-octenoate | S | 0.24 ± 0.04 | 0.30 ± 0.01 | 0.24 ± 0.00 | 0.31 ± 0.03 |
| | V | 0.51 ± 0.00 | 0.42 ± 0.05 | 0.42 ± 0.10 | 0.62 ± 0.09 |

and 4-methyl pentan-1-ol were recorded. Aldehydes, which represent a significant group of volatiles in plum fruit, were produced at moderate levels during the shelf life period, except for (Z)-2-hexenal, which increased tenfold. There was a slight increase during storage compared to the initial concentrations recorded at harvest, while CA storage increased ester concentrations by about half, compared to the highest levels seen after 26 days of storage in air. Sufficient oxygen in ambient atmosphere supports the process of esterification. The atmosphere with higher $CO_2$ concentrations (CA2) gradually reduced the biosynthesis of flavour volatiles and simultaneously increased the rate of fermentation (Fig. 6; Table 1a-1d). Volatile esters were decreased by raising $CO_2$ levels and lowering $O_2$ levels in storage, especially when both gas levels were combined. Others have also noted that high $CO_2$ levels appear to suppress the production of volatiles (FELLMAN et al., 2000; SINGH et al., 2010; STREIF et al., 2010).

## Acknowledgements

Table 1c: Volatile compounds determined by SPME (µg/kg) for treatments and duration of storage
   *(cont.)*

| Compounds | Cv. | IN | FAN | | CA1 | |
|---|---|---|---|---|---|---|
| | | 0 days | 26 days | 61 days | 26 days | 61 days |
| Ethyl (Z)-3-hexenoate | S | 37.26 ± 4.86 | 46.47 ± 0.00 | 22.09 ± 0.00 | 39.41 ± 7.43 | 22.92 ± 0.00 |
| | V | 40.27 ± 5.44 | 35.96 ± 4.20 | 26.47 ± 5.29 | 28.41 ± 4.90 | 25.53 ± 2.47 |
| Butyl acetate | S | - | 171.3 ± 0.0 | - | - | - |
| | V | 265.3 ± 17.1 | 329.3 ± 20.1 | - | 199.2 ± 0.0 | - |
| Butyl 2-methylbutyrate | S | 326.1 ± 37.5 | 377.9 ± 35.3 | 172.6 ± 36.4 | 350.2 ± 58.7 | 157.2 ± 21.6 |
| | V | 433.1 ± 23.3 | 632.1 ± 52.1 | 280.0 ± 29.2 | 378.8 ± 72.8 | 306.8 ± 28.5 |
| n-Hexyl butanoate | S | 9.47 ± 1.68 | 11.11 ± 1.13 | 13.65 ± 2.14 | 6.66 ± 1.16 | 4.72 ± 2.00 |
| | V | 14.88 ± 2.40 | 11.21 ± 0.89 | 7.09 ± 0.61 | 6.37 ± 1.10 | 4.89 ± 1.44 |
| (Z)-Geraniol | S | 29.56 ± 3.88 | 21.43 ± 5.36 | 37.75 ± 5.63 | 57.58 ± 20.46 | 6.98 ± 2.99 |
| | V | 34.17 ± 4.83 | 43.04 ± 18.11 | 14.95 ± 5.51 | 64.45 ± 26.78 | 5.21 ± 1.83 |
| Nerol | S | 1.23 ± 0.23 | 0.68 ± 0.09 | 2.33 ± 0.54 | 2.04 ± 1.53 | 0.64 ± 0.23 |
| | V | 1.21 ± 0.45 | 1.82 ± 0.98 | 0.97 ± 0.20 | 2.45 ± 0.80 | 0.39 ± 0.12 |
| Limonene | S | 1181 ± 460 | 933.5 ± 118.8 | 146.9 ± 6.9 | 784.4 ± 162.1 | 95.62 ± 15.26 |
| | V | 1168 ± 645 | 2400 ± 93 | 170.3 ± 20.7 | 290.8 ± 78.5 | 184.9 ± 24.1 |
| b-Ionone | S | 3.56 ± 0.26 | 2.72 ± 0.98 | 1.70 ± 0.55 | 2.58 ± 0.43 | 0.89 ± 0.07 |
| | V | 8.99 ± 1.94 | 7.14 ± 0.60 | 4.76 ± 0.37 | 4.70 ± 1.81 | 7.80 ± 1.39 |
| a-Farnesene | S | 9.68 ± 0.73 | 10.95 ± 0.00 | - | 9.83 ± 0.35 | - |
| | V | 17.94 ± 1.54 | 13.48 ± 1.13 | 11.96 ± 0.80 | 11.81 ± 4.30 | 17.72 ± 0.77 |

Table 1d: Volatile compounds determined by SPME (µg/kg) for treatments and duration of storage
   *(cont.)*

| Compounds | Cv. | CA2 | | RA | |
|---|---|---|---|---|---|
| | | 26 days | 61 days | 26 days | 61 days |
| Ethyl (Z)-3-hexenoate | S | 33.28 ± 6.98 | 30.84 ± 9.13 | 62.96 ± 0.00 | 16.36 ± 0.00 |
| | V | - | 23.68 ± 3.50 | 56.72 ± 5.97 | 79.23 ± 61.52 |
| Butyl acetate | S | - | - | 407.0 ± 0.0 | - |
| | V | 721.2 ± 275.9 | - | 413.2 ± 7.7 | - |
| Butyl 2-methylbutyrate | S | 310.4 ± 25.6 | 322.2 ± 23.2 | 197.0 ± 43.9 | 75.15 ± 6.33 |
| | V | 378.0 ± 122.2 | 272.0 ± 30.9 | 230.8 ± 23.8 | 125.6 ± 40.8 |
| n-Hexyl butanoate | S | 4.23 ± 0.53 | 6.44 ± 1.23 | 17.21 ± 2.48 | 5.04 ± 1.01 |
| | V | 4.95 ± 0.29 | 4.66 ± 1.22 | 15.34 ± 7.18 | 15.78 ± 2.92 |
| (Z)-Geraniol | S | 45.22 ± 2.52 | 39.25 ± 7.93 | 38.48 ± 22.46 | 13.32 ± 6.98 |
| | V | 18.06 ± 1.03 | 5.20 ± 0.00 | 41.55 ± 20.42 | - |
| Nerol | S | 1.40 ± 0.09 | 1.95 ± 0.24 | 1.98 ± 1.31 | 1.30 ± 0.25 |
| | V | 0.58 ± 0.01 | 0.42 ± 0.00 | 2.16 ± 1.20 | - |
| Limonene | S | 1747 ± 160 | 204.2 ± 14.9 | 264.8 ± 59.2 | 51.82 ± 3.72 |
| | V | 252.0 ± 82.9 | 168.2 ± 22.6 | 144.7 ± 4.9 | 81.70 ± 20.45 |
| b-Ionone | S | 1.97 ± 0.82 | 2.59 ± 0.49 | 0.99 ± 0.27 | 2.37 ± 0.01 |
| | V | 4.81 ± 2.46 | 1.69 ± 1.52 | 5.70 ± 2.35 | 4.19 ± 0.60 |
| a-Farnesene | S | 7.21 ± 0.88 | 9.86 ± 2.13 | - | 8.02 ± 0.00 |
| | V | 16.03 ± 0.00 | 11.42 ± 1.57 | 13.09 ± 0.07 | 12.87 ± 2.12 |

Table 2: Effects of the various factors (plum varieties, storage atmospheres and storage time)

| compounds | Factor | | | Interactions | | |
|---|---|---|---|---|---|---|
| | treatment | time | cultivar | cultivar x treatment | cultivar x time | treatment x time |
| Ethanol | < 0.0001 | < 0.0001 | 0,0007 | 0,0876 | < 0.0001 | < 0.0001 |
| 2-Methylbutan-1-ol | 0,0042 | < 0.0001 | 0,0022 | 0,1538 | 0,3338 | 0,0018 |
| 3-Methylbutanal | < 0.0001 | < 0.0001 | 0,0262 | 0,0053 | 0,0796 | < 0.0001 |
| n-Hexan-1-ol | < 0.0001 | < 0.0001 | 0,0063 | 0,0188 | 0,0065 | 0,0012 |
| 2-Methyl pentan-1-ol | < 0.0001 | < 0.0001 | 0,1768 | 0,0119 | 0,102 | < 0.0001 |
| 2-Methylbutanal | < 0.0001 | < 0.0001 | 0,8791 | 0,0064 | 0,6423 | < 0.0001 |
| (Z)-2-Hexenal | 0,0074 | < 0.0001 | 0,1872 | 0,0038 | 0,1321 | < 0.0001 |
| Ethyl acetate | 0,0004 | 0,0026 | 0,1596 | 0,4118 | 0,1479 | 0,0007 |

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