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**COMUNICACIÓN**

# Fruit firmness, ground color and ethylene evolution in two cultivars of peach *(Prunus persica* L. Batsch)

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**SUMMARY**

Ethylene evolution was studied and related to fruit softening and change in ground color, in the peach cultivars: July Elberta and Red Globe. Loss of firmness and a more yellow ground color was accompanied by an increase in ethylene evolution. During the earliest phases of softening, whole fruit ethylene production rose only slightly and the highest values were detected when the fruit had already softened.

**Key Words:** peach, ethylene, ground color, firmness

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**RESUMEN**

Se estudió la liberación de etileno y su relación con el ablandamiento de la pulpa y los cambios de color de fondo en duraznos de los cultivares July Elberta y Red Globe. La liberación de etileno acompañó el ablandamiento de los frutos y los cambios de color en el epicarpio de los frutos. Durante las primeras fases del ablandamiento de los frutos la producción de etileno se incrementó ligeramente, alcanzando sus máximos valores cuando el fruto ya se encontraba blando.

**Palabras clave:** durazno, etileno, color de fondo, firmeza.

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Fruit ripening involves a series of biochemical and structural changes that make the fruit acceptable for eating. In climacteric fruits, these changes are under the control of the plant hormone ethylene (Pech *et al.,* 1994). The sharp increase of ethylene production which occurs at the initiation at the onset of the climacteric phase is the key phenomenon controlling the initiation of changes in color, aromas, texture and flavor (Tonutti *et al.,* 1991; Pech *et al.,* 1994). Peaches as many others climacteric fruits accelerate ripening after harvest, as compared to fruits remaining on the tree (Loney *et al.,* 1974 cited by Abeles *et al.,* 1992). This fact could result from the cessation of supply of the ripening inhibitor (Sfakio-takis and Dilley, 1973) or it is also possible that picking fruit results in a stress condition, and ripening is induced by internal stress signals (Abeles *et al.,* 1992). However, Huber (1983) reviewing the role of cell wall hydrolases in fruit softening emphasized that the wall hydrolysis was an important early event in avocado fruit ripening and that, in D'Anjou pears, softening preceded ethylene production and the respiratory climacteric. And Ventura (1995) suggest that ripening and ethylene production are simultaneous events. Furthermore (Tonutti *et al.,* 1996) reported that during the earliest phases of softening, whole-fruit ethylene production rose only slightly, so peach should be listed among those fruit species in which the ethylene climacteric coincides with or follows the eating ripeness stage. In the results of Aly *et al.* (1981) figures of ethylene evolution and firmness that showed a simultaneous evolution of ethylene and loss of firmness in peach and nectarine were presented. This study was undertaken to understand better the time-course of ethylene evolution in relation to softening and ground color in peach.

Research was carried out at a commercial orchard of Villa Retiro, Córdoba with cvs Red Globe and July Elberta. Red Globe trees were trained as free palmette (3 x 4 m) and July Elberta trees were trained in a globular form (5x5 m). Fruits were harvested from homogenous trees, at two dates: July Elberta (16 and 20/12/96) and Red Globe 20 and 25/12/96. At each harvesting date, forty seven fruits, homogeneous in size and skin ground color, were chosen.

Ethylene evolution and ground color, was evaluated on twelve fruits once a day for five days or until eating ripeness stage. On other seven fruits ethylene evolution, firmness, ground color soluble solids content (SSC), pH and titratable acidity (TA) were evaluated daily for five days or until eating ripeness stage. Ethylene determination: At each harvesting date, fruits were separately enclosed in 700ml sealed jars. After three hours of incubation, 5 ml air samples were withdrawn from each jar and injected into a gas

**Table 1**. Whole fruit ethylene evolution in peach cvs. Red Globe and July Elberta in two harvest dates.

| Cultivar | Days after Harvest | Ethylene Evolution (nl/g.h.) First Harvest | | Second Harvest | |
|---|---|---|---|---|---|
| Red Globe | 0 | 0,0000 a[y] | A[z] | 0,0855 a | B |
| | 1 | 0,0000 a | A | 0,1809 ab | B |
| | 2 | 0,0268 ab | A | 0,1764 ab | B |
| | 3 | 0,0634 b | A | 0,1880 b | B |
| | 4 | 0,1396 c | A | 0,2023 b | A |
| | 5 | 0,1296 c | A | 0,2052 b | A |
| July Elberta | 0 | 0,0054 a | A | 0,0146 a | A |
| | 1 | 0,0403 a | A | 0,3544 b | B |
| | 2 | 0,0753 ab | A | 0,3839 b | B |
| | 3 | 0,1415 b | A | 0,3866 b | B |
| | 4 | 0,0882 ab | A | 0,3825 b | B |

(y) Mean separation in column by Duncan test at 5 % level in each cv.

(z) Mean separation in file by Duncan test at 5 % level.

chromatograph equipped with a flame ionization detector and an PORAPACK column for ethylene determination. Column temperature was maintained at 100 °C (injector 110 °C) (Tonutti *et al.,* 1991). Fruit firmness was evaluated with a penetrometer (Effegi, Italy): measurements were performed on two opposite sides of each fruit, the peel was removed prior to pressure testing (El Agamy *et al.,* 1981). Fruit ground color evolution was measured with a Minolta Chroma Meter CR 300 (Bible and Singha, 1993). Chemical analysis: fruit mesocarps were homogenized in a blender and allowed to rest until a semi-clear juice was obtained, the juice was used for analysis: pH, SSC and TA. SSC and acidity of fruit juice was determined using a T/C hand refractometer and the NaOH titration method, respectively (El Agamy *et al.,* 1981). The acidity was expressed as percentage of malic acid. Both differences among harvest days and cultivars were tested for significance by an analysis of variance.

Different patterns of ethylene evolution? have been detected between harvest dates in cv Red Globe and between cvs Red Globe and July Elberta, also reported by Aly *et al.*, 1981, El Agamy *et al.,* 1981 and Tonutti *et al.,* 1996. Ethylene evolution was detected at the harvest day in cv July Elberta at both harvest dates and only at the second harvest date in cv Red Globe. Ethylene evolution in Red Globe was detected two days after harvest at the first harvest date (table 1). The increase of ethylene evolution was simultaneous to loss of firmness and the maximum production occurred after the fruit was near to the eating ripeness stage. The loss of firmness and yellowing of ground color occurred gradually at the first harvest date and roughly at the second harvest date, in both cvs, (table 2 y 3). Ethylene production at the first harvest date was bigger than at the second one. It was evident that harvested fruits lose firmness and change ground color more quickly than fruits remaining on the tree. SSC was similar between the first and second harvest date in cv. Red Globe (table 2); but in cv July Elberta SSC increased as time on tree was prolonged (table 3).

These results, showing simultaneous ethylene evolution, loss of firmness and disappearance of green color in the tested cvs Red Globe, July Elberta coincides with results reported by Callahan *et al.* (1992) and Tonutti *et al.* (1996) working with other cultivars. And as Ventura (1995) and Tonutti *et al.* (1996) discussed, peaches should be listed among those fruit species in which the ethylene climacteric coincides with or follows the eating ripening stage. Three explanations may be essayed: a) a sharp increase of ethylene production should not be necessary at the onset of the climacteric phase, and a very low ethylene concentration (Prattella, 1992), undetectable by actual gas chromatography, should be enough to trigger the initiation of changes in color, aromas, texture and flavor. This first hypothesis is not likely however, since in slow-ripening nectarines ethylene production was reduced and ripening was delayed or reduced compared with cv Fantasia (Brecht and Kader, 1984). b) Abeles *et al.,* 1992, discussing about "tree factor" in apples, and Brecht and Kader (1984) working with slow-ripening nectarines suggested that apple softening and ethylene production are not related facts and loss of firmness and yellowing were not controlled by endogenous ethylene levels. At both harvest dates, July Elberta fruits reached an eating ripeness stage, but with different ethylene production levels. The reason is unknown, but this fact may be considered as another evidence of the lack of relationship between ethylene evolution and the onset of ripening in peaches. c) Tonutti, *et al.* (1991) observed that an increase in ethylene evolution both in the whole fruit and in the epicarp is preceded by an increase in ethylene evolution in the mesocarp and the dramatic increase in EFE activity in the epicarp during the climacteric might be responsible for the relatively high amount of ethylene produced by whole-fruit. These observation should explain loss of firmness previous to the whole fruit maximum ethylene evolution. However, nothing was found about the relationship between yellowing of fruit and ethylene. It is evident that more information is needed about ethylene evolution and ripening to understand the real importance of this growth regulator in peach ripening.

**Table 2.** Whole fruit ethylene and maturity index evolution in Red Globe peaches at two harvest dates.

| Harvest Date | Days after Harvest | Ethylene Evolution (nl/g.h.) | Ground Color (a value) | Firmness (lbs) | SSC (Brix) | PH | AT (% malic acid) |
|---|---|---|---|---|---|---|---|
| 20/12/96 | 0 | 0,0000 a[y] | 7,46 a | 15,14d | 9,7 a | 3,55 a | 0,79 b |
| | 1 | 0,0000 a | -6,59 a | 13,89 d | 10,0a | 3,71b | 0,86 c |
| | 2 | 0,0268 ab | -4,29 b | 9,58 c | 10,9 b | 3,82 cd | 0,62 a |
| | 3 | 0,0634 b | -1,48 c | 5,98 bc | 11,5b | 3,76 bc | 0,81 b |
| | 4 | 0,1396 c | 2,33 d | 3,37 b | 11,7b | 3,89 d | 0,83 bc |
| | 5 | 0,1296 c | 4,15e | 1,50 a | 11,5b | 3,90 d | 0,80 b |
| 25/12/96 | 0 | 0,0855 a | -4,77 a | 15,10c | 11,74 a | 3,67 a | 0,83 c |
| | 1 | 0,1808 ab | -2,45 b | 4,28 b | 11,20 a | 3,71 b | 0,49 a |
| | 2 | 0,1763 ab | 0,66 c | 2,05 a | 11,03a | 3,97 b | 0,62 b |
| | 3 | 0,1880 b | 4,07 d | 1,23 a | 11,40a | 3,97 b | 0,66 b |
| | 4 | 0,2022 b | 5,73 d | 0,90 a | | | |
| | 5 | 0,2051 b | 7,79 e | 0,88 a | | | |

(y) Mean separation in columns by Duncan test at 5% level by harvest date.

**Table 3.** Whole fruit ethylene and maturity index evolution in July Elberta peaches at two harvest dates.

| Harvest Date | Days after Harvest | Ethylene Evolution (nl/g.h.) | Ground Color (a value) | Firmness (lbs) | SSC (Brix) | PH | AT (% malic acid) |
|---|---|---|---|---|---|---|---|
| 16/12/96 | 0 | 0,0054 a | -8,39 a | 13,20 c | 9,4 a | 3,87 c | 0,75 a |
| | 1 | 0,0403 a | -6,07 b | 8,40 b | 10,0 ab | 3,69 a | 0,83 ab |
| | 2 | 0,0753 ab | -4,95 b | 3,25 a | 10,6 bc | 3,68 a | 0,78 ab |
| | 3 | 0,1415 b | -2,65 c | 1,99 a | 11,3cd | 3,78 b | 0,97 bc |
| | 4 | 0,0882 ab | 0,69 d | 1,52a | 11,8 d | 3,78 b | 0,87 c |
| 20/12/96 | 0 | 0,0146 a | -3,24 a | 8,75 c | 9,9 a | 3,62 a | 0,78 ab |
| | 1 | 0,3544 b | -0,73 b | 2,94 b | 11,8b | 3,66 a | 0,83 b |
| | 2 | 0,3839 b | 2,20 c | 1,68 ab | 12,2 b | 3,94 b | 0,62 a |
| | 3 | 0,3866 b | 3,83 cd | 0,68 a | 13,0 b | 4,00 b | 0,66 a |
| | 4 | 0,3825 b | 4,92 d | | | | |

(y) Mean separation in columns by Duncan test at 5% level by harvest date.

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