Nonmelting-flesh Trait in Peaches Is Not Related to Low Ethylene Production Rates

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Abstract. The notion that ethylene production levels in nonmelting-flesh (NMF) peach (Prunus persica L.) fruit are normally lower than those in melting-flesh (MF) fruit is refuted in our study. In fact, NMF fruit (‘Oro A’ and FL 86-28C) usually produced higher levels of ethylene than did MF fruit (FL 90-20 and ‘TropicBeauty’). In both MF and NMF peaches, the rate of ethylene production, rather than the respiration rate, provided a good indication of the developmental stage of the fruit at harvest. Ethylene content in fruit on the tree followed a climacteric pattern, with the level in ‘Oro A’ (NMF) and FL 90-20 (MF) peaking at 50 and 12 μL·L⁻¹, respectively. The respiratory climacteric was not apparent in either ‘Oro A’ or FL 90-20, and levels of CO₂ were similar in both genotypes.

Along with sensory and compositional changes, peaches exhibit a rise in their respiratory activity during ripening (Amoros et al., 1989; Lim and Romani, 1964; Looney et al., 1974). This rise follows the typical climacteric pattern (Lill et al., 1989; Looney et al., 1974). Relative to other horticultural commodities, peaches have a moderate respiration rate during ripening, with CO₂ production rates ranging from 59 to 102 mg·kg⁻¹·h⁻¹ at 20 °C (Hardenburg et al., 1986; Kader and Mitchell, 1989). Variations in the rate of respiration have been observed for different varieties, maturities, climatic conditions, and cultural practices (Kader and Mitchell, 1989).

A climacteric surge in the production of ethylene is also observed during the ripening of peaches (Amoros et al., 1989; Looney et al., 1974; Miller et al., 1988; Tonutti et al., 1991) and nectarines (Brecht and Kader, 1984a, 1984b), and the level can be 10-fold that in preclimacteric fruit (Miller et al., 1988). According to Amoros et al. (1989), the peak levels of ethylene and CO₂ occur at about the same time. The rate of ethylene production during ripening of peaches reportedly ranges from 0.1 to 140 μL·kg⁻¹·h⁻¹ at 20 °C (Kader and Mitchell, 1989). Ethylene production increases with a rise in temperature (Kader and Mitchell, 1989), is reduced by low oxygen levels (Kader et al., 1982; Ke et al., 1991), can be either increased or decreased by elevated CO₂ (Kader and Mitchell, 1989; Kader et al., 1982; Kubo et al., 1990), and varies widely among genotypes (Kader and Mitchell, 1989).

The natural variability existing in peach flesh firmness has allowed for the fruit to be classified as either melting- (MF) or nonmelting-flesh (NMF). The main distinction between the two types is that NMF fruit lack the rapid loss of firmness, known as “melting of the fruit,” characteristic of the final stages of ripening of MF fruit (Lester et al., 1996). While significant decreases in cheek and blossom-end firmness were detected during maturation of both MF and NMF fruit, the decline was substantially greater in MF fruit (Brovelli et al., 1995, 1998). Furthermore, sensory evaluation of MF and NMF fruit indicated that although no flavor differences could be detected, a clear distinction in fruit texture could be established between the two types (Brovelli et al., 1995, 1999).

It has been reported that the biological basis for differences in flesh firmness between MF and NMF peaches is related to differences in their capacity for ethylene production (Biggs et al., 1982; El-Agamy et al., 1981). In nectarines, Brecht and Kader (1984c, 1984d) reported a relationship between the slow-ripening trait of four selections and their inability to produce the levels of ethylene found in normally ripening varieties.

The purpose of our study was to determine whether MF and NMF peaches differed substantially in ethylene production. Additionally, we determined the effect of harvest date and fruit size on the rates of respiration and ethylene production.
A set of 16 uniformly sized fruit on three trees were designated for the measurement of ethylene or CO₂ and labeled accordingly. A rubber serum stopper (size 14; Fisher Scientific, Pittsburgh) was attached to the fruit’s exocarp in the cheek area using a noncorrosive silicon rubber adhesive (3140 RTV Coating; Dow Corning, Midland, Mich.), which does not produce ethylene and is not injurious to the peel (P.D. Petracek, personal communication). Prior to attachment to the fruit, the stoppers were autoclaved for an hour to drive off all ethylene. Gas samples were removed through the septa with syringes and analyzed by gas chromatography as described for off-the-tree measurements.

Results and Discussion

The pattern of ethylene production over time for fruit harvested in 1994 reflected the different developmental stages at which the fruit were harvested. Upon collection, fruit of FL 86-28C and 'TropicBeauty' from the first, second, and third harvests were at the preclimacteric, climacteric rise, and climacteric peak, respectively (Fig. 1). 'Oro A' and FL 90-20 fruit exhibited similar patterns of ethylene production (data not shown).

The pattern of ethylene production for fruit of FL 86-28C and 'TropicBeauty' from the first harvest in 1995 was a good indicator of the developmental stage as related to diameter (Fig. 2). In general terms, fruit from the second harvest, whether MF or NMF, were at a more advanced phase in their ethylene production pattern than those from the first harvest (data not shown).

The climacteric peak of ethylene production was distinctively higher in the two NMF genotypes than in the two MF genotypes (Figs. 1 and 2). Data for 'Oro A' and FL 90-20 (not shown) were similar to those for FL 86-28C and 'TropicBeauty'. At the third harvest of 'TropicBeauty' and FL 86-28C, ethylene production was similar for both genotypes, but the climacteric was not well defined and trends were difficult to compare (Fig. 1). The higher levels of ethylene production in NMF fruit contrast with reports by El-Agamy et al. (1981) and Biggs et al. (1982) that the biological basis of the slow-softening trait (NMF) in peaches was a reduced capability for ethylene production.

Fruit developmental stage and respiratory drift were not clearly related (Fig. 3). The maximum rate of CO₂ production observed for NMF genotypes ranged from 40 to 100 mL·kg⁻¹·h⁻¹ and that for MF genotypes from 40 to 50 mL·kg⁻¹·h⁻¹, but a climacteric respiratory pattern was not readily apparent.

Ethylene production by fruit on the tree followed a climacteric pattern for both 'Oro A' and FL 90-20 (data not shown). However, the same distinction between MF and NMF fruit noted in ethylene production off the tree was also apparent in the measurements on the tree. The average peak level of ethylene was 50 µL·L⁻¹ for 'Oro A' (NMF) and 12 µL·L⁻¹ for FL 90-20 (MF). Levels of CO₂ for fruit on the tree were similar in both genotypes. Unlike the production of ethylene, which showed a clear climacteric trend, the levels of CO₂ tended to fluctuate more, making the respiratory climacteric indefinite (data not shown).

According to our observations, ethylene production by NMF fruit both on and off the plant is higher than, or at best similar to, that of
MF fruit, thus refuting the hypothesis that low levels of ethylene production are responsible for the NMF trait in peaches.

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