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Aroma Generation by Horticultural Products: What Can We Control? Introduction to the Workshop

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Aroma, as is true for many quality attributes of fresh and processed fruit and vegetable products, is affected by the culture of the plant material prior to consumption. Culture, in this case, refers to the cultivar selection and production and postharvest processes that affect the physiology of the plant. In this workshop, we will focus on the effects of cultural tools on the biology of aroma generation by horticultural commodities. Importantly, the aroma of some fresh horticultural products [e.g., strawberry (*Fragaria × ananassa* Duch.), tomato (*Lycopersicon esculentum* Mill.), and apple (*Malus × domestica* Borkh.)] has received an increasing amount of attention from both producers and consumers because of perceived deficiencies in the sensory quality of commercially produced cultivars, so perhaps the time is ripe for strengthening efforts to improve our understanding of this important attribute.

We have loosely grouped commodities into three distinct classes, based on the manner in which the product is typically consumed and the means by which the bulk of the compounds with aromatic character impact are generated. One class of plant products is usually consumed after some form of thermal treatment that affects the synthesis of aromatic compounds. Within this group one might place the edible portions of, for example, sweetpotato [*Ipomoea batatas* (L.) Lam.], potato (*Solanum tuberosum* L.), spinach (*Spinacea oleracea* L.), and green beans (*Phaseolus vulgaris* L.). A second class is consumed fresh, but some form of cellular disruption, and the mixing of cellular constituents normally held apart by cellular compartmentation, are

responsible for the formation of characteristic aromas. Among this group, one could include, for example, edible portions of tomato, blueberry (*Vaccinium* sp.), spinach, and radish (*Raphanus sativus* L.). In the third class, the production of characteristic aroma compounds is spontaneous, relying primarily on the developmental stage of the organ. Important in this class are fruits such as apples, bananas (*Musa* sp.), strawberries, and peaches [*Prunus persica* (L.) Batsch.].

These three classifications are somewhat artificial in that they integrate the habits of the consumer (some plant materials are consumed either fresh or cooked) and the biology of the plant. Further, the volatile profile will probably comprise compounds that are synthesized via more than one of the three routes described. Cellular disruption occurs, for instance, in all plant products as they are processed or consumed, and aromas attending this disruption will necessarily contribute to the mixture of compounds with olfactory activity. Nevertheless, there are advantages to the classifications, as they permit a focused presentation and discussion of biological systems that affect final aroma and, by extension, the manner in which plant processes can be altered by cultural techniques to affect the product.

The first of the four papers in this workshop (Kays and Wang, 2000) approaches the subject of thermally induced aromas. As part of the discussion, the authors describe the process of flavor perception by humans, segregating and then integrating the influences of taste and aroma on flavor. Flavor perception is the process linking plant biochemistry with the physiology and psychology of the consumer and is a particularly interesting and difficult area of inquiry. The authors proceed to develop the concept of thermal induction of aromas, using the sweetpotato as a primary example, and conclude with a discussion of selection through plant breeding and preharvest factors as they

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affect aroma. Among the interesting features of this work is the activity of enzymes critical to flavor development during the heating process.

The second paper in the workshop (Baldwin et al., 2000) focuses on the cell disruption-dependent synthesis of aroma in tomato. These authors also treat the subject of aroma perception, with additional perspective on the complexity and sensitivity of aroma detection by humans and other herbivores. Among the concepts discussed is the importance of the odor threshold of aromas as it pertains to perception, as well as its use as a descriptive tool. Considerable attention is given to the biochemistry of aroma generation following tissue disruption, with a discussion of possible target enzymes for improving aroma.

The third and fourth papers describe the process of spontaneous aroma generation for strawberry (Forney et al., 2000) and apple (Fellman et al., 2000) fruit. The biosynthesis of esters figures prominently in both crops. The crops differ, however, in that apple can be said to have a specific character-impact compound such as hexyl acetate or ethyl 2-methylbutyrate, whereas no such compound exists for strawberry, the aroma of which is only apparent when a mixture of esters and other volatiles are present. In both papers, the importance of cultivar and postharvest handling procedures is discussed at some length.

The task of preserving and improving the aroma of horticultural products will probably be difficult. For instance, some treatments currently used to prevent decay, or to preserve texture and color, can compromise aroma quality. Elevated CO₂, for example, is commonly used to reduce decay in strawberry and other berry crops, but can induce fermentation (Beaudry, 1993; Ke et al., 1991). Similarly, reduced O₂ levels, while extending the storage-life of apple and other pome fruit, can reduce aroma and, at stress levels, cause off-flavors (Brackmann et al., 1993). Perhaps more to the point, the task of improving our understanding through scientific inquiry appears daunting. The metabolic pathways responsible for the synthesis of aroma compounds are diverse and often highly integrated with other portions of both primary and secondary metabolism. Even so, we are poised on the brink of new breakthroughs. For instance, the protein required for the biosynthesis of esters has been characterized (Pérez et al., 1993; Ueda and Ogata, 1977) and the gene controlling its synthesis recently

identified (Aharoni et al., 2000). As we develop a better understanding of the genetic and biochemical factors that alter or control synthesis of aroma, we should be able to develop better cultural tools to maintain and/or improve flavor. We hope that the proceedings from this workshop will inspire plant scientists with these possibilities and instigate new, much-needed research.

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