Environmentally Friendly and Safe Technologies for Quality of Fruits and Vegetables

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Authors are responsible for content and accuracy of their papers.

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SECTION 2. PRE-HARVEST FACTORS AFFECTING POSTHARVEST QUALITY AND SAFETY

09. PREHARVEST FACTORS AFFECTING FRUIT QUALITY AND SAFETY

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Abstract

Quality of fruit and vegetables is defined at harvest, and postharvest technologies only ensure that the rate at which products' quality decline is minimized. Fruit growers are faced with the problem of producing enough quantities to be profitable but also to produce with high intrinsic quality. For consumers, flavor and safety are the most important characteristics of quality. The main factors that affect flavor quality are the genotype (cultivars/rootstocks), maturity at harvest, environment and cultural practices and the cross effect between them. Pest and diseases control with pesticides, the use of growth regulators to improve quality and consumer acceptance also play an important role in cultural practices and are firmly related to safety. Some examples of preharvest factors influencing quality and safety of fruits will be discussed, given that postharvest quality is based both on better flavor and safer products, as well as in long shelf life and high acceptability. In the future, producers will have to identify all factors that influence composition and quality and to use environmental friendly technologies that are able to increase postharvest quality.
Keywords: cultural practices, environment, flavor, genotype, safety

Introduction

Quality of fruit and vegetables is defined at harvest, and postharvest technologies only ensure that the rate at which products' quality decline is minimized. Producers must ensure that they deliver the highest quality into the supply chain. This can only be achieved through continuous consolidation and vertical integration among producers and marketers (Hewett 2006). Fruit growers are faced with the problem of producing enough quantities to be profitable and simultaneously, to produce with high intrinsic quality. Most are certified under one of the on-farm assurance systems, like GLOBALGAP, that ensure that Good Agricultural Practices are undertaken and that relationship between consumers, farmers and marketers is strengthened.

For consumers, flavor and safety are the most important characteristics of quality. Kader (2008) in a recent review emphasizes the importance of flavor quality of fruits and vegetables to increase their consumption. Consumers' demand drives organic production expansion and as such, in most western countries, organic retail sales continue to rise. Organic versus conventional production system inputs may affect phytochemical and nutrient content, the ripening pattern and the marketing and food sensory qualities (Perkins-Veazie & Lester 2008). These changes require new postharvest assessments.

From the scientific point of view, in the last decade quality of fruit and vegetables has been the center of attention; ISAFRUIT is one of the EEC projects that focus on fruit quality, involving 200 researchers from 60 Research and Development Institutions. Commercially, packinghouses started to use nondestructive methods, like NIR spectrometry, to measure intrinsic quality (Solid Soluble Content, SSC) and research groups are developing sensor technologies, like E-nose and E-tongue, which may soon be available.

Some examples of preharvest factors influencing quality and safety of fruits will be discussed, given that postharvest quality is based both on better flavor and safer products, as well as in long shelf life and high acceptability.

Quality and safety

Taste and smell related to fruit's composition (mainly sugar, acid and phenolic content) are of the outmost importance in fruit quality (Kader 2008). Appearance, textural and nutritional quality are other quality components also important to consumers but repeated purchases are dependent upon flavor quality. The main factors that affect flavor quality are the genotype (cultivars/rootstocks), maturity at harvest, environment and cultural practices and the cross effect between them. Pest and diseases control with pesticides, the use of growth regulators to improve quality and consumer acceptance also play an important role in cultural practices and are firmly related to safety.

Genotype

The genotype has more importance to flavor than any other factor, in other words fruit quality is foremost an inherent cultivar trait. For example, Hakala *et al*. (2003) compared mineral composition and vitamin C of six strawberry cultivars produced both through normal farming and organically cultivated; they found that genotype and origin had a larger effect than cultural practices. Breeding programs focus now on quality, developing new cultivars with higher sugars, moderate acids, lower phenolics compounds and higher vitamins content. This is done through conventional methods or using molecular markers to indentify quantitative traits loci (QTLs or candidate genes) for physical and chemical components of fruit quality. An increasing number of QTLs have been identified in apple, melon, peach, almond, apricot, cherry, strawberry, grape, raspberry, cocumber and tomato, that will permit identifying important enzymes involved in flavor pathways. In some cases, like tomato, introgression lines obtained through crosses between tomato and a wild relative, allowed the study of quantitative traits loci and the creation of new varieties by introducing exotic traits. Another step of biotechnology is the design of transgenic fruits and vegetables with higher quality characteristics, like the genetic modified strawberry or the table grape with the defH9-iaaM auxin-synthesizing gene (Mezzetti *et al.* 2004; Costantini *et al.* 2007) but society does not seem to be ready to accept them (Hewet 2006).

Rootstock is a factor of lesser importance than cultivar; nevertheless in citrus it may affect many quality characters. According to Castle (1995) citrus is a crop with minor canopy management and fruit quality depends on plant water relations and sugar transport, whereas in deciduous fruit trees fruit quality relies on factors related to crop load and canopy management.

Kader (2008) rates maturity (after genotype) as the second most important factor influencing flavor quality of fruits and vegetables. In order to provide better tasting fruits and vegetables, optimizing maturity /ripeness stage in relation to flavor should be a goal.

Environmental factors

Orchard design (spacing and row orientation), training systems (Y, V-trellis or vertical axes) with well spaced branches and improved light distribution maximize yield and fruit quality. In fruit trees, yield is related to the total amount of sunlight intercepted, for example in apples, this relation is linear below 60 % of light interception (Lakso 1994). Establishing open and well exposured tree canopies, through cultural practices, as pruning, is essential for obtaining a high potential yield. Red color in some fruits, like apple and pear, requires direct incident light. Solar radiation in combination with cool nights is reported to promote *de novo* synthesis of anthocyanins in fruits (Tromp & Wertheim 2005). Temperature and other weather constraints (rain distribution, frost, hail and wind) greatly affect quality. In warm climates, fruits have more SSC and earlier ripening. Topography and site exposure affect both harvest date and SSC, for example, in Cova da Beira – Portugal, a region of cherry production, earlier cherry maturation was found in south-eastern exposures orchards and SSC was higher in cherries from the western exposure orchard (Costa 2006).

Cultural practices

Trees nutritional status and soil management are accountable for a great number of postharvest disorders, therefore an optimum mineral balance has to be found in each case. High levels of nitrogen and irrigation result in fruits with less sugar and vitamins, with poor texture and more prone to disorders and diseases.

Color is affected by high levels of nitrogen or by nutrients imbalances, for example, in citrus, delayed time to color break, reduced color at harvest, thick rind and less juice result from heavy nitrogen and low phosphorus fertilizations (Ritenour *et al.* 2002). Another well known example is the greater N:Ca and K:Ca ratios in albino strawberry fruits when compared to colored fruits. Ca and K increase firmness and storage capacity and lack of calcium in the fruit is known to be the main reason for several problems. Since there are numerous factors affecting fruit's calcium accumulation (Faust 1989) calcium sprays may not always work. This is due to interactions with other nutrients and with water status, crop load and fruit size. Regulated deficit irrigation (RDI) improves water use efficiency and fruit quality, mainly SSC, and it is increasingly adopted in different fruit crops (Behboudian & Mills 1997).

Pesticides and growth regulators sprays are of major concern as they affect quality and safety, therefore new technologies and new pesticides are under development to reduce residues level. Still, fruit industry uses several growth regulators with different goals, as to increase fruit set in pears, for thinning apples, to prevent fruit drop, to increase fruit size or to increase firmness or color. Concerning pesticides, some diseases have origin in latent fungal infection of fruit in the orchard (*Stemphylium vesicarium, Phytophthora* spp*., Venturia pirina, Mucor piriformis, Nectria galligena, Alternaria alternata, Pezicula malicorticis, Pezicula alba).* In Portugal, *Stemphylium* in pears is an increasing concern resulting in postharvest losses. Weather conditions, cultivar and physiological fruit condition (as fruit maturity at harvest) are relevant to disease development. Thus, new fungicides and treatments which can protect fruit after harvest are under development. In summary, "orchard health" depends not only on weather conditions but also on cultural practices and optimal integrated crop management is determinant to reduce pesticide sprays.

Some examples of cultural practices that increase fruit quality without chemicals are based on crop manipulation, like ringing and scoring (Goren *et al.* 2004) or light manipulation. Reflective ground covers, which help trees to harvest light, improve red skin coloration and advance maturity, fruit size and SSC. Alternatives to chemical thinning can be shading with nets, as shown by recent studies in Swiss and Italy with apple trees (Widmer 2007; Domingos 2008) or mechanical thinning through devices that are now under development (Shupp *et al.* 2008).

It is not easy to assess the differences in fruit nutrient contents when comparing different production systems. Bourne & Prescott (2002) summarized several studies comparing inorganic and organic fertilizers: results were too variable to provide definitive conclusions. The most common problem relates to consider, the same cultivar, same soil, microenvironment, orchard age, fruit size position in the canopy in both production systems (Perkins-Veazie & Lester 2008). In a particular study done over ten years, comparing the influence of organic and conventional crop management practices on the content of flavonoids in tomato, Mitchell *et al*. (2007) found that the levels of flavonoids increased over time in samples from organic treatments, whereas the levels of flavonoids did not vary significantly in conventional treatments. It seems that there is a trend toward higher levels of phenolic antioxidants, ascorbic acid and soluble solids in organic foods, however, more research examining relationships between agricultural production systems and nutrient content is needed.

In the future, producers will have to identify all factors that influence composition and quality and to use environmental friendly technologies that are able to increase postharvest quality.

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