QUALITY ASSURANCE OF HARVESTED HORTICULTURAL PERISHABLES

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Abstract

An effective quality assurance (QA) system throughout the handling steps between harvest and retail display is essential to provide a consistently good-quality supply of fresh horticultural crops to the consumers and to protect the reputation of a given marketing label. QA starts with the selection of the genotype and its proper time to harvest for the best appearance, textural, flavor (taste and aroma), and nutritional (including phytonutrients) quality. Careful harvesting and handling are required to minimize physical injuries. Each postharvest handling step has the potential to either maintain or reduce quality and in a few cases (such as ripening of climacteric fruits) improve eating quality. The availability of low-cost microcomputers and solid-state imaging systems have resulted in increased use of computer-aided video inspection to sort many products into two or more quality grades before marketing. Objective and non-destructive methods of differentiating horticultural perishables on the basis of their flavor and nutritional quality are being tested and will become excellent QA tools as they become more reliable and efficient. Safety assurance can be part of QA and its focus is on minimizing chemical and microbial contamination during production, harvesting, and postharvest handling of intact and fresh-cut fruits and vegetables. Future research and development efforts should focus on developing better methods of monitoring quality and safety attributes of fresh produce as part of a QA system.

1. Quality attributes

Quality of fresh produce includes appearance (size, shape, color, gloss, and freedom from defects and decay), texture (firmness, crispness, juiciness, mealiness, and toughness, depending on the commodity), flavor (sweetness, sourness (acidity), astringency, aroma, and off-flavors), and nutritive value (vitamins, minerals, dietary fiber, phytonutrients). The relative importance of each quality component depends on the commodity and the individual's interest (Kader, 1992). Most postharvest researchers, producers, and handlers are product-oriented in that quality is described by specific attributes of the product itself, such as sugar content, color, or firmness. In contrast, consumers, marketers, and economists are more likely to be consumer-oriented in that quality is described by consumer wants and needs (Shewfelt, 1999). Although consumers purchase fresh produce based on appearance and textural quality, their repeat purchases depend upon their satisfaction with flavor (taste and aroma). They are also interested in the health-promoting attributes and nutritional quality of fresh fruits and vegetables (Kader, 1988).

Several attempts have been made to develop portable instruments with sensors that detect volatile production by fruits as a way to detect maturity and quality. Other strategies include the removal of a very small amount of fruit tissue and measurement of total sugars or soluble solids content. Near-infrared detectors have great potential for nondestructive estimation of sugar content in fruits (Abbott, 1999). Until such methods become widely available, we will continue to depend on destructive techniques, such as soluble solids determination by a refractometer and titratable acidity measurement by titration, to evaluate flavor quality of fruits. Table 1 summarizes the proposed minimum

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soluble solids content and maximum titratable acidity for acceptable flavor quality of fruits. These values will not guarantee the optimum flavor quality for each consumer but it assures a minimum acceptability level for the majority of consumers. Additional research will likely result in a few changes in the values shown in Table 1. Use of these indices in a quality assurance program must be coupled with tolerances of deviation from the proposed averages because of the large variation among cultivars, production areas and seasons, maturity at harvest and ripeness stage at the time of evaluation.

2. Quality control and assurance

Quality control (QC) is the process of maintaining an acceptable quality level to the consumer. Quality assurance (QA) is the system whose purpose is to assure that the overall QC job is being done effectively (Hubbard, 1999). QA and QC are often used interchangeably to cover the planning, development, and implementation of inspection and testing techniques; they take time and a lot of training. A successful QA/QC system cannot be flexible, but it must be subject to constant review and improvement as conditions change (Hubbard, 1999).

Many attempts are currently being made to automate the separation of a given commodity into various grades and the elimination of defective units. The availability of low-cost microcomputers and solid-state imaging systems has made computer-aided video inspection on the packing line a practical reality. Solid-state video camera or light reflectance systems are used for detection of external defects, and x-ray or light transmittance systems are used for detecting internal defects (Abbott et al, 1997; NRAES, 1997). Further development of these and other systems to provide greater reliability and efficiency will be very helpful in quality control efforts.

An effective quality control and assurance system throughout the handling steps between harvest and retail display (Table 2) is required to provide a consistently good-quality supply of fresh horticultural crops to the consumers and to protect the reputation of a given marketing label. Quality control starts in the field with the selection of the proper time to harvest for maximum quality. Careful harvesting is essential to minimize physical injuries and maintain quality. Each subsequent step after harvest has the potential to either maintain or reduce quality; few postharvest procedures can improve the quality of individual units of the commodity (Cavalieri, 1999; Kader, 1988; Kader, 1992; Shewfelt *et al*., 1993).

Exposure of a commodity to temperatures, relative humidities, and/or concentrations of oxygen, carbon dioxide, and ethylene outside its optimum ranges will accelerate loss of all quality attributes. The loss of flavor and nutritional quality of fresh intact or cut fruits and vegetables occurs at a faster rate than the loss of textural and appearance quality. Thus, QC/QA programs should be based on all quality attributes and not only on appearance factors as often is the case. More research is needed to identify the reasons for the faster loss of flavor than appearance quality and to develop new strategies for extending postharvest-life based on flavor to match that based on appearance.

3. Standardization and inspection of fresh produce

Grade standards identify the degrees of quality in a commodity that are the basis of its usability and value. Such standards, if enforced properly, are essential tools of quality assurance during marketing and provide a common language for trade among growers, handlers, processors, and receivers at terminal markets. Some production areas like California, USA enforce minimum standards concerning produce quality, maturity, container, marking, size and packing requirements. This provides orderly marketing and equity in the marketplace and protects consumers from inedible and poor quality produce. The California Department of Food and Agriculture is also responsible for enforcing provisions of laws governing the sale of foods labeled as organic.

The U.S. standards for fresh fruit and vegetable grades are voluntary, except when

required by industry marketing orders, by the buyer, or for export marketing. The USDA, Agricultural Marketing Service is responsible for developing, amending, and implementing grade standards (for more information access the following website: http://www.ams.usda.gov/standards). Inspection is done either on a continuous basis (where one or more inspectors are assigned to a packinghouse to make frequent quality checks of the commodity along the packing lines), or on a sample basis (where representative samples of a prescribed number of boxes out of a given lot are randomly selected and inspected to determine whether the product meets the grade specification for which it is packed). When inspection is completed, certificates are issued by the inspector on the basis of applicable official standards.

To ensure uniformity of inspection: (1) inspectors are trained to apply the standards, (2) visual aids (color charts, models, diagrams, photographs and the like) are used whenever possible, (3) objective methods for determining quality and maturity are used whenever feasible and practical, and (4) good working environments with proper lighting are provided. Recently, the Fresh Products Branch of the USDA's Agricultural Marketing Service equipped inspectors with digital cameras and enhanced computer technology for taking and transmitting images of produce or containers. AMS is offering the images to applicants over the Internet as an additional resource in its fresh fruits and vegetables inspection service. Inspectors also use the imaging to confer with produce quality experts working in USDA's headquarters in Washington, D.C. The imaging provides a quick, visual confirmation of product appearance and defects, damage from shifted loads, brands and container markings, and container condition. It can facilitate "ecommerce" (buying and selling produce via the Internet) and help the produce industry quickly resolve disputes over the quality or condition of shipments.

International standards for fruits and vegetables were introduced by the Organization for Economic Cooperation and Development beginning in 1961, and now there are standards for about 40 commodities. Each includes three quality classes with appropriate tolerances: Extra class = superior quality (equivalent to "U.S. Fancy"); Class I = good quality (equivalent to "U.S. No. 1"); and Class II = marketable quality (equivalent to "U.S. No. 2"). Class I covers the bulk of produce entering into international trade. These standards or their equivalents are mandatory in the European Union countries for imported and exported fruits and vegetables.

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Useful Websites

http://postharvest.ucdavis.edu
http://www.fao.org/inpho
http://www.usda.gov

Tables

1. Proposed minimum soluble solids content (SSC) and maximum titratable acidity (TA) for acceptable flavor quality of fruits (Kader, 1999).

Fruit	Minimum SSC%	Maximum TA%
Apple	10.5-12.5 (depending on cultivar)	
Apricot	10	0.8
Blueberry	10	---
Cherry	14-16 (depending on cultivar)	
Grape	14-17.5 (depending on cultivar) or SSC/TA ratio of 20+	
Grapefruit	SSC/TA ratio of 6+	
Kiwifruit	14	---
Mandarin	SSC/TA ratio of 8+	
Mango	12-14 (depending on cultivar)	
Muskmelons	10	---
Nectarine	10	0.6
Orange	SSC/TA ratio of 8+	
Papaya	11.5	---
Peach	10	0.6
Pear	13	---
Persimmon	18	---
Pineapple	12	1.0
Plum	12	0.8
Pomegranate	17	1.4
Raspberry	8	0.8
Strawberry	7	0.8
Watermelon	10	---

2. Quality assurance procedures during handling of horticultural perishables.

Handling Steps	Quality Assurance Procedures
Harvesting	Training workers on proper maturity and quality selection, careful handling, and protecting produce from sun exposure.
Packinghouse Operations	Checking product maturity, quality, and temperature upon arrival. Implementing an effective sanitation program to reduce microbial load. Checking packaging materials and shipping containers to ensure they meet specifications. Training workers on proper grading by quality (defects, color, size), packing, and other packinghouse operations. Inspecting a random sample of the packed product to ensure that it meets grade specification. Monitoring product temperature to assure completion of the cooling process. Maintaining effective communications with quality inspectors and receivers to correct any deficiencies as soon as they are identified.
Transportation	Inspecting all transport vehicles before loading for functionality and cleanliness. Training workers on proper loading and placement of temperature-recording devices in each load. Keeping records of all shipments as part of the “trace-back” system.
Handling at Destination	Checking product quality upon receipt and moving it quickly to the appropriate storage area. Shipping product from distribution center to retail markets without delay and on a first in/first out basis unless its condition necessitates a different order.