EVALUATION OF QUALITY TRAITS

The word "quality" is used in various ways in reference to fresh fruits and vegetables such as market quality, edible quality, shipping quality, table quality, nutritional quality, internal quality, and appearance quality.

A "trait" defines aspects of quality of produce. Each crop has a specific and different set of quality traits.

The quality of fresh horticultural commodities is a combination of physical and chemical characteristics, attributes, and properties that give the commodity value for food (fruits and vegetables) and enjoyment (ornamentals). Producers are mainly concerned that their commodities have good appearance and the cultivar must have high yield, disease resistance, ease of harvest, and shipping quality. On the other hand, receivers and market distributors are mostly concerned about appearance quality, they are also keenly interested in firmness and long storage life. Consumers consider good-quality fruits and vegetables to be those that look good, firm, and offer good flavor and nutritive value. Although consumers buy on the basis of appearance and feel, their satisfaction and repeat purchases are dependent upon good edible quality. Assurance of safety of the products sold is extremely important to the consumers.

Components of Quality

Various components of quality are used to evaluate commodities in relation to specifications for grades and standards, selection in breeding programs, and evaluation of responses to various environmental factors and postharvest treatments. The relative importance of each quality factor depends upon the commodity and its intended use (fresh or processed).

Appearance factors are the most important quality attributes of ornamental crops. Many defects influence the appearance quality of horticultural crops. Morphological defects include sprouting of potatoes, onions, and garlic; rooting of onions etc. Physical defects include shriveling and wilting; internal drying of some fruits; mechanical damage such as punctures, cuts and deep scratches, splitting and crushing, skin abrasions and scuffing, deformation and bruising; growth cracks and so on. Physiological defects include temperature-related disorders (freezing, chilling, sunburn, sunscald) such as puffiness of tomatoes, black heart of potatoes etc. Pathological defects include decay caused by fungi or bacteria and virus-related blemishes, irregular ripening, and other disorders. Other defects result from damage caused by insects, birds, and hail; chemical injuries, and scars, scabs, and various blemishes.

The texture of horticultural crops is important for eating and cooking quality and is a factor in withstanding shipping stresses. Soft fruits cannot be shipped long distances without extensive losses due to physical injuries. In many cases, this necessitates harvesting fruits at less than ideal maturity for flavor quality.

Evaluating flavor quality involves the perception of tastes and aromas of many compounds.

Fresh fruits and vegetables play a significant role in human nutrition, especially as sources of vitamins (C, A, B6, thiamine, niacin), carbohydrates, proteins, lipids, minerals and dietary fiber. Fruits and vegetables also supply important nutrients like magnesium, iron, and other nutrients including folacin, riboflavin, zinc, calcium, potassium, and phosphorus.

Safety factors include levels of naturally occurring toxicants in certain crops (glycoalkaloids in potatoes), contaminants such as chemical residues and heavy metals, microbial contamination and mycotoxin.

List of quality components of fresh fruits and vegetables

Main factors	Components
Appearance	Size: dimensions, weight, volume Shape and form: diameter/depth, ratio, compactness, uniformity Color: uniformity, intensity Defects: external, internal Morphological, Physical and mechanical Physiological, Pathological and entomological
Texture	Firmness, hardness, softness, succulence, juiciness Toughness, fibrousness
Flavor	Sweetness, Sourness, Astringency, Bitterness, Aroma (volatile compounds), Off-flavors and off-odors
Nutritional value	Carbohydrates (including dietary fiber), Proteins Lipids, Vitamins and Minerals
Safety	Naturally occurring toxicants, Contaminants (chemical residues, heavy metals), Mycotoxins, Microbial contaminants

FACTORS INFLUENCTNG QUALTTY

Many pre- and postharvest factors influence the composition and quality of fresh horticultural crops. These include genetic factors (selection of cultivars and rootstocks), pre-harvest environmental factors (climatic conditions and cultural practices), maturity at harvest, harvesting method and post-harvest handling procedures.

Climatic conditions

Climatic factors, especially temperature and light intensity, have a strong influence on the nutritional quality of fruits and vegetables. The location and season in which plants are grown can determine their ascorbic acid, carotene, riboflavin, and thiamine content. Light is one of the most important climatic factors in determining ascorbic acid content of plant tissues. In general,

the lower the light intensity, the lower is the ascorbic acid of plant tissues. Although light does not play a direct role in the uptake and metabolism of mineral elements by plants, temperature influences the nutrient supply because transpiration increases with higher temperatures. Rainfall affects the water supply to the plant, which may influence composition of the harvested plant part.

Cultural practices

Soil type, the rootstock used for fruit trees, mulching, irrigation, and fertilization influence the water and nutrient supply to the plant, which can affect the nutritional composition of the harvested plant part. Cultural practices such as pruning and thinning determine the crop load and fruit size, which can influence the nutritional composition of fruit. The use of agricultural chemicals, such as pesticides and growth regulators, does not directly influence fruit composition but may indirectly affect it due to delayed or accelerated fruit maturity.

Maturity at harvest

This is one of the main factors determining compositional quality and storage life of fruits and vegetables. All fruits with few exceptions, reach peak eating quality when fully ripened on the tree. However, since they cannot survive the postharvest handling system, they are usually picked mature but not ripe. Tomatoes harvested green and ripened at 20°C to table ripeness contain less ascorbic acid than those harvested at the table-ripe stage.

Harvesting method

The method of harvest can determine the variability in maturity and physical injuries and can consequently influence the nutritional composition of fruits and vegetables. Mechanical injuries such as bruising, surface abrasions and cuts can accelerate loss of vitamin C. The incidence and severity of such injuries are influenced by the method of harvest, management of harvesting, and handling operations.

Postharvest handling procedures

Delays between harvesting and cooling or processing can result in direct losses (due to water loss and decay) and indirect losses (lowering of flavor and nutritional quality). The extent of such losses is related to the condition of the commodity when picked and is strongly influenced by the temperature of the commodity which can be several degrees higher than ambient temperatures, especially when exposed to sunlight. Temperatures higher than those that are optimum for the commodity increase the loss of rate of vitamin content, especially vitamin C.

METHODS FOR EVALUATING QUALITY

Quality evaluation methods can be “destructive” or “non-destructive”. They include objective scales based on instrument readings and subjective methods based on human judgement using hedonic scales.

APPEARANCE QUALITY

1. **Size**

Dimensions: Measured with sizing rings, calipers.

Weight: Correlation is generally good between size and weight; size can also be expressed as numbers of units of commodity per unit of weight.

Volume: Determined by water displacement or by calculation from measured dimensions

2. **Shape**

Ratio of dimensions: diameter/depth ratio; used as index of shape in fruits.

Diagrams and models of shape: Some commodity models are used as visual aids for quality inspectors

3. **Color**

Uniformity and intensity: Important appearance qualities

Visual matching: Using color charts, guides and dictionaries to match and describe colors of fruits and vegetables

Light reflectance meter: Measures color on the basis of the amount of light reflected from surface of the commodity; examples include Minolta Colorimeter, Gardner and Hunter Color Difference Meters (tristimulus colorimeters), and Agtron E5W spectrophotometer.

Light transmission meter: Measures light transmitted through the commodity. It can be used to determine internal color and various disorders, such as water core of apples and black heart of potatoes.

Measurement of delayed light emission related to the amount of chlorophyll in plant tissues; can be used to determine color based maturity stages

Determination of pigment content: Evaluates the color of horticultural crops in pigment content, i.e., chlorophylls, carotenoids and flavonoids.

4. **Presence of defects (internal and external)**

Incidence and severity of defects are evaluated by using a five grade scoring systems such as 1= no symptoms, 2= slight, 3= moderate, 4= severe and 5= extreme or a seven or nine point hedonic scale if more categories are needed. Objective evaluation of external defects using computer-aided vision techniques appears promising.

Internal defects can be evaluated by non-destructive techniques, such as light transmission and absorption characteristic of the commodity, sonic and vibration associated with the mass density and elasticity of the material.

TEXTURAL QUALITY

1. **Yielding quality (firmness and softness)**
   Stand-mounted testers: Determine penetration force using testers with a more consistent speed of punch such as the UC Fruit Firmness Tester and the Effegi penetrometer mounted on a drill stand.
   Laboratory testing: Fruit firmness can be determined by measuring penetration force using an Instron Universal Testing machine or a Texture Testing system, or by measuring fruit deformation using a Deformation Tester.
2. **Fibrousness and toughness**
   Shear force: Determined using an Instron or a Texture Testing system.
   Resistance to cutting: Determined by using a Fibrometer.
   Chemical analysis: Fiber content or lignin content.
3. **Succulence and juiciness**
   Measurement of water content: An indicator of succulence or turgidity.
   Measurement of extractable juice: An indicator of juiciness.
4. **Sensory textural qualities**
   Sensory evaluation procedures: Evaluate grittiness, crispness, mealiness, chewiness and oiliness.

FLAVOR QUATITY

1. **Sweetness**
   Sugar content: Determined by chemical analysis procedures for total and reducing sugars or for individual sugars; indicator papers for quick measurement of glucose in certain commodities, such as potatoes.
   Total soluble solids content: Measured using refractometers or hydrometers; can be used as indicator of sweetness because sugars are major component of soluble solids. Other constituents that contribute to total soluble solids include soluble pectins, organic acids, amino acids, and ascorbic acid.
2. **Sourness (acidity)**
   pH (hydrogen ion concentration) of extracted juice: Determined using a pH meter or pH indicator paper.
   Total titratable acidity: Determined by titrating a specific volume of the extracted juice with 0.1 N NaOH to pH 8.1, then calculating titratable acidity as citric, malic. or tartaric acid (depending on which organic acid predominates in the commodity).
3. **Saltiness**

Fresh vegetables and fruits: Usually not applicable.

4. **Astringency**
   Determined by taste testing or by measuring tannin content, solubility, and degree of polymerization.
5. **Bitterness**
   Determined by taste testing or by measurement of the alkaloids or glucosides responsible for the bitter taste.
6. **Aroma (odor)**
   Determined by sensory panels in combination with identification of volatile components responsible for specific aroma of a commodity (using gas chromatography-mass spectrometry).
7. **Sensory evaluation**
   Human subjects: Judge and measure combined sensory characteristics (sweetness, sourness, astringency, bitterness, overall flavor intensity) of a commodity.
   Laboratory panels: Detect and describe differences among samples; determine which volatile compounds are organoleptically important in a commodity.
   Consumer panels: Indicate quality preferences.

NUTRITIOINAL VALUE

Various analytical methods are available to determine total carbohydrates, dietary fiber, proteins and individual amino acids, lipids and individual fatty acids, vitamins, and minerals in fruits and vegetables. Several public and private laboratories have automated equipment for food analysis for use in situations where nutritional labeling is required and large numbers of samples have to be analyzed routinely.

SAFETY FACTORS

Analytical procedures, using thin-layer chromatography, gas chromatography, and high- pressure liquid chromatography, are available for determining minute quantities of the following toxic substances:

1. naturally occurring toxicants, such as cyanogenic glucosides in lima beans and cassava, nitrates and nitrites in leafy vegetables, oxalates in rhubarb and spinach, thioglucosides in cruciferous vegetables, and glycoalkaloids (solanine) in potatoes
2. natural contaminants, such as fungal toxins (mycotoxins), bacterial toxins and heavy metals (mercury cadmium, lead)
3. synthetic toxicants, such as environmental contaminants and pollutants, and residues of agricultural chemicals

QUALITY CONTROL AND ASSURANCE

An effective quality control and assurance system throughout the handling steps between harvest and retail display 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. Minimum acceptable flavor of fruits can be assured by determining their soluble solids content and titratable acidity. 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 the individual units of the commodity.

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 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 detecting of external defects, and X-ray or light transmittance systems are used for detecting internal defects. Further development of these and other systems to provide greater reliability and efficiency will be very helpful in quality control efforts.