color values. Visual evaluation techniques, used originally to describe color characteristics, and their pitfalls were described. The visual approach has been largely superseded by instrumental measurements. The available instrumentation and some of the color scales currently employed were discussed. Types of instruments in use range from simple narrow-band filter color comparators, through broad-band tristimulus instruments to full spectrum spectrophotometers. For practical use with fruits and vegetables, most are employed in reflectance mode. Examples of the instruments were shown. Most frequently used instrumental color scales are based on tristimulus values. Specific scales have been developed for various fruit and vegetable products to indicate color characteristics deemed desirable.

ON-LINE QUALITY MEASUREMENTS OF FRUITS AND VEGETABLES

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On-line sensing of fresh produce has been an important area of research and development since the early 1950's. The goal of such processes has been to identify fruits and vegetables that meet certain grade criteria and to then segregate the product based on such criteria. An overall grading system can be subdivided into three parts: sensing, classification and actuator components. Coupled with this grading system must be a handling system for product presentation to the sensor, indexing of the product and a mechanism for category diversion into the desired product streams. The rationale for such automation has been the high cost and unreliability of a labor force for seasonal work which is monotonous and somewhat arduous. Also, the consistency and accuracy of machine-based grading may be higher than that of manual grading. Such systems may also have more flexibility in adjusting acceptable standards. For example, packing a premium grade for export or upscale domestic markets would be desirable.

An ideal sensor system should be reliable, durable, environmentally immune, small in size and non-intrusive. Also, high resolution and accuracy are desirable but are usually considered trade-off factors with overall costs. The microprocessor decision making portion of such units must work in real-time. For most packinghouse operations, the speed requirements are 20 to 100 decisions per second. The amount of data can vary extensively from single inputs, e.g., mass, to digital image processing, typically 256 x 256 arrays or greater. New computer modeling tools are now becoming available for data analysis that more closely emulate the human decision making process. The next generation of automatic grading equipment will no doubt have "trainable classifiers" based on neural networks or pattern recognition concepts. It is envisioned that automatic grading will eventually offer packers the ability to analyze for features, especially internal quality attributes, that the current manual grading cannot discern.