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Light Scattering for Predicting Quality of Apple Fruit

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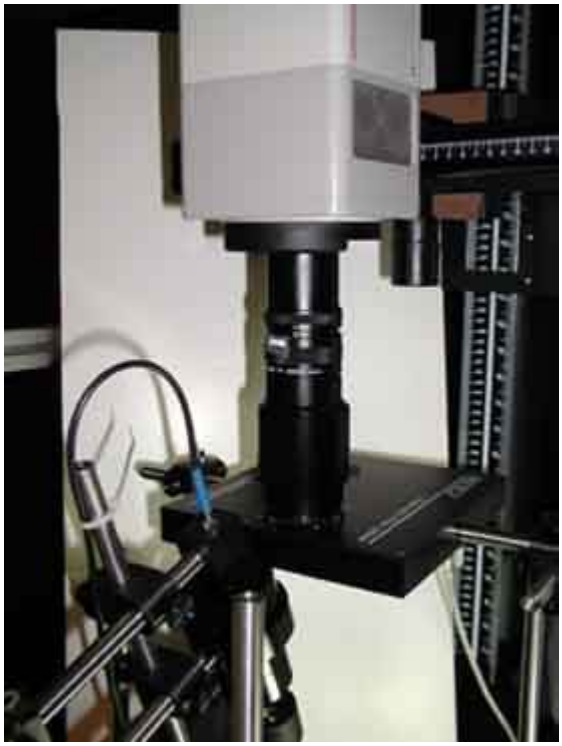
When it comes to the quality of apples, consumers look for texture and flavor, especially firmness and sweetness. Some people like apples to taste crisp and sour, others may want them less hard but sweet. Fruit sold in a local grocery store often look great in appearance, but they may not taste great. Appearance can be useful for determining maturity and the time to harvest, but it is not a reliable indicator of flavor and texture. Too often we find that fruit of the same or similar color can have very different texture and flavor. One bad tasting apple could turn away consumers to other food products since they now have so many choices when buying food. Poor, inconsistent quality fruit can cause millions of dollars of losses to fruit growers because wholesalers and/or retailers refuse to sale them to consumers.

Over decades researchers have investigated different nondestructive techniques that would allow us to measure, grade and sort apples without destroying them. Past research has been primarily focused on using mechanical methods, such as force/deformation, impact, vibration, and sonics to measure fruit firmness. Although these methods have shown some success, they have not been used for grading and sorting fruit due to either their unsatisfactory performance or the technical difficulty of implementing these methods for online grading and sorting of fruit. Recent research is more focused on using optical techniques to measure the internal quality of fruit. Near-infrared spectroscopy (NIRS), a technique that measures diffusely reflected or transmitted light over a range of wavelengths longer than those of the visible light, has been found to be useful for predicting the sweetness of apples and other fresh fruits. Commercial application of NIRS for sorting apples and other fruits for sweetness has started recently in other countries and this country as well. However, sorting for firmness still presents a great challenge.

Dr. Lu is measuring firmness using a texture analyzer



Multispectral imaging for predicting firmness and sugar of apples

In our laboratory, we are exploring a new optical technique to simultaneously measure the firmness and sweetness of apple fruit. When a light beam is incident upon an apple fruit, a small fraction of the light will be reflected at the surface (called surface or specular reflection) and the majority of the light will penetrate into the fruit. Some of the penetrated light will be scattered and reflected back to the surface (diffuse reflectance); some will go through the whole fruit and emerge from the opposite site of the fruit (transmittance); and the remaining will be absorbed in the fruit. Absorption and scattering (including both diffuse reflectance and transmittance) are two basic phenomena when light interacts with matter. Our research is based on the hypothesis that light absorption is related to certain chemical constituents of the fruit such as sugar and acid, whereas light scattering is more closely associated with the density and structures of the fruit tissue. We are developing a multispectral imaging technique to quantify light scattering in the fruit at selected wavelengths. As a sharp, focused light beam hits the fruit, it generates backscattered light at the surface of the fruit. By measuring the light scattering characteristics at the selected wavelengths or bands, we may be able to relate them to the quality of apple fruit. In our recent study, we demonstrated that this technique is useful for predicting both firmness and sugar content of apple fruit. We were able to predict fruit firmness with a correlation coefficient of 0.87 and the prediction error less than 1.3 lb., a minimal resolving value a trained panelist can predict. We also obtained good predictions of the sugar content of apples with the prediction error about 0.9 ºBrix. These results indicate that the technique is promising for assessing and grading apple fruit for internal quality. Research is continuing to improve the multispectral imaging system and computer algorithms so that we can achieve real-time grading of apple fruit for firmness and sugar content. The technique could eventually be used for grading and sorting apples at packinghouses to ensure superior, consistent apple fruit delivered to the consumer.