NEAR-INFRARED SPECTROSCOPY PROGRESS REPORT

Rich Ozanich
Berkeley Instruments Inc.
Richland, WA
rozanich@msn.com

PROGRESS REPORT

This report gives a brief update on previous and current applications of near-infrared (NIR) spectroscopy for measuring maturity and quality parameters of tree fruit. Prior funding from the Washington State Tree Fruit Research Commission allowed the development of a broad base of knowledge and applications experience. This base of research capability has since attracted private funding to bring NIR equipment and methods from research prototypes to commercial products. An overview of NIR spectroscopy is shown in Figure 1. New work described here was privately funded.

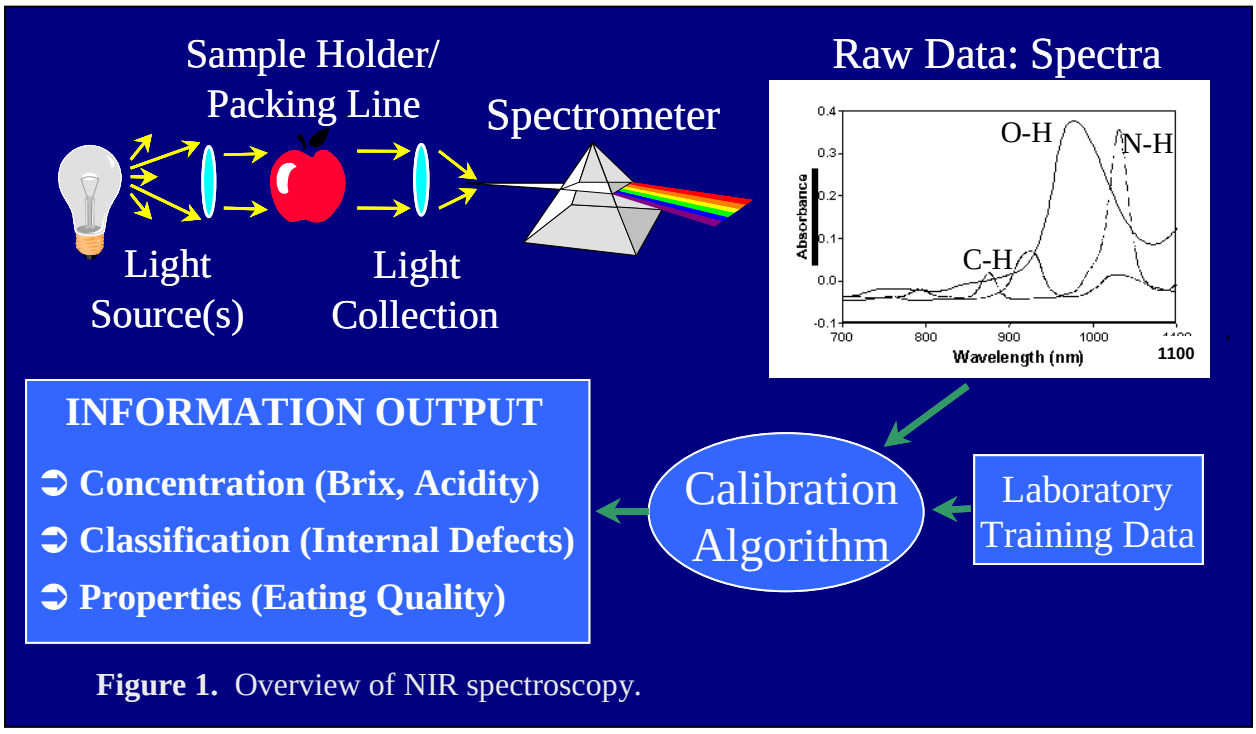

Figure 1. Overview of NIR spectroscopy.

Previous work has demonstrated that NIR can measure a variety of parameters in whole fruit. Soluble solids (referred to here as sugar content or brix) can be measured with high correlation and standard errors of 0.5° brix (Figure 2). Manual placement/positioning of fruit improves correlation and accuracy, although rolling fruit can still be measured with good correlation and standard errors of 0.6° brix. Total acidity (as malic acid) can also be measured in whole apples with moderate correlation and standard errors of approximately 0.1% total acidity (Figure 3). Correlation of punch-test firmness with NIR has also been demonstrated, although a standard error of approximately 1.5 pounds limits the usefulness for NIR firmness prediction of apples.

Applying NIR to the measurement of moving fruit on a packing/sorting line poses particular challenges. Apples are typically sorted at line speeds of 6 to 8 fruit per second and line speeds of 10 fruit per second can be necessary for some applications. These high speeds require measurement times well below 0.1 second per fruit.

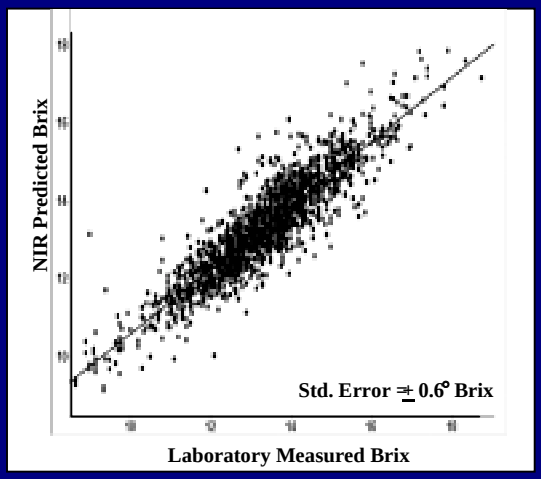

Figure 2. Correlation of NIR and laboratory measured brix.

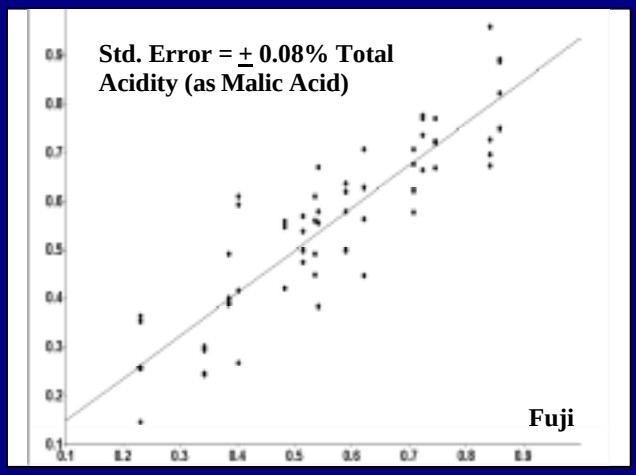

Figure 3. Correlation of NIR and laboratory measured total acidity.

During this brief period, the NIR measurement should strive to be representative of the whole fruit. This is necessary because of the inherent variation of properties within individual fruit. Fruit ripens from the inside out and during this maturation process; there is a gradient in properties such as sugar content. Even mature fruit has natural variation in properties such as sugar and acid content from one side to another.

One example of the high variation of sugar content within an apple is a blush Golden Delicious. Although the localized and near-surface region of the blush can be 3 to 5% higher brix, the overall contribution to the whole apple brix average is usually relatively small.

It is particularly important in these cases that the NIR measurement be representative of the whole fruit, or significant errors will be incurred. To be representative of the whole fruit, the NIR measurement must be based on light that has been transmitted deep into the fruit (NIR transmission), rather than light that is primarily from the surface (NIR reflectance). All work here used NIR transmission for measuring whole fruit, which also allows the detection of moderate to severe internal disorders such as watercore, internal browning and rot (Figure 4).

To assess the validity of the on-line NIR equipment, four devices were fabricated and mounted in series on a single packing-line (Figure 5). A total of 1000 Red Delicious, Golden Delicious, and Fuji apples were measured as they were rolling at a line speed of six fruit per second. The performance of the NIR devices was compared based on data collected during a single rolling pass. The 1000 predicted brix values for each of the four NIR devices were used to compute an average predicted brix for the entire lot of 1000 apples for each of the four NIR devices. The average predicted brix for all four NIR devices were within 0.2 brix of one another. The average standard deviation between the predicted and actual brix was <0.6 brix for all four NIR devices.

Figure 4. NIR transmission detection of internal disorders.

ACKNOWLEDGEMENTS

Berkeley Instruments, Inc. would like to acknowledge the Washington State Tree Fruit Research Commission for their generous support over the last four years and our recent commercial partners who have invested in bringing NIR from technical prototype to commercial production.

Figure 5. Comparison of four NIR packingline sensors.