Refractometer Calibration, Use and Maintenance

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Harvest season will soon be upon us in the San Joaquin Valley, which means that testing fruit for maturity will become a daily task. Proper sampling for sugar is important for making decisions on harvesting specific varieties or locations. Often referred to as "soluble solids" or "sugar" testing, fruit maturity evaluation involves sample collection and testing procedures that accurately represent the crop. Testing for sugar content in fruit has become easier as technology has improved. However, improved technology cannot eliminate deficiencies in sample collection or errors caused by poor refractometer care and maintenance. Reviewing the following tips should improve the accuracy and utility of sugar data in determining fruit maturity.

Choosing and Using a Handheld Refractometer

There are two types of handheld refractometers: analog and digital (Fig. 1). They work on the principle that light entering a prism has a unique characteristic. That characteristic is represented by a value on a scale in units known as ºBrix. When light enters a dry prism, the field of view in an analog refractometer remains blue (Fig. 2). In a digital refractometer, an error message would appear. Both are indications that the light is not being interfered with as it passes through the prism.

Pure water placed on the refractometer should result in a reading of zero (Fig. 3). A solution containing sucrose (table sugar or fruit juice) placed on the prism surface will change the direction of the light significantly. Depending on the amount of sucrose in solution, the ºBrix will range from 0 to 25+ for most agricultural crops. In Figure 4, an analog refractometer displays a reading from a sample that is 17 ºBrix.

Handheld analog refractometers are convenient because they do not require an energy source. However, they may not be accurate if used outside the specified temperature range. Older refractometers will give accurate readings only when the temperature is at 68ºF (20ºC). Both the refractometer and the sample of juice must be at this temperature. When temperatures are above or below optimal, a corrections table is needed to determine actual ºBrix. Readings can be as much as 0.89 ºBrix lower when the temperature is 50ºF (10ºC) if a correction is not made. If samples are being evaluated at temperatures close to room temperature, the difference is probably of little practical significance. However, if evaluations are being made outdoors in the heat, then it is important to adjust the readings by a given factor provided by the manufacturer. Newer refractometers compensate for fluctuations in temperature, but are still only accurate within a specified range of temperatures. A range between 68-86ºF (20-30ºC) is the most common for temperature compensated (TC)

Figure 1. Types of available refractometers. The two on the left are digital and the two on the right are analog.

or automatic temperature compensation (ATC) refractometers. Refractometers with larger ATC ranges are available, but are more expensive.

Samples evaluated in the heat on a San Joaquin Valley summer day will result in inaccurate readings. If using a non-ATC refractometer, as the temperature increases, accuracy of the reading will be compromised. Accuracy improves when samples are taken back to a lab or office for processing at room temperature. Figure 5 shows the variability in ºBrix readings from samples evaluated at different times of the day. Note that testing samples during hot weather can give a "false" increase in actual ºBrix. Deciding whether the difference is significant will depend on how close you are to the critical range for decision-making regarding harvest.

If using an analog refractometer, whenever possible, all samples within a specific field or block should be read by one person, since readings are somewhat subjective.

Handheld digital refractometers are convenient, often have ATC, and readings are less subjective. Batteries are needed and should be replaced each season. Juice samples are deposited into a well that allows a light-emitting diode (LED) to reflect light through the prism. A liquid crystal display (LCD) screen displays the ºBrix reading in seconds. As quickly as you can clean the well with water and dry it, the next sample can be tested. In addition to the hot Valley sun affecting digital refractometers when outside of the optimal ATC range, bright light can interfere with accuracy. Shading the sample well will eliminate the interference from sunlight.

Whichever style of refractometer you choose, it is important to identify your objective and determine what options are important to you. Analog refractometers are popular with growers because they are easy to use and relatively inexpensive (approximately $100-200). A digital refractometer will usually result in more rapid readings and more accurate data (approximately $300).

Calibration

Calibrating the refractometer is the first step in evaluating sugar content of fruit. It is an easy but often neglected task. Calibration verifies the zero baseline reading, ensuring that subsequent fruit juice sample readings are accurate. Fruit harvest decisions based on inaccurate sugar readings can impact quality, storage durability and sales. Refractometers should be calibrated at the beginning of each use and, depending on how many samples are being measured, periodically throughout the sampling process.

Proper calibration requires a pure water source and testing solutions of known sucrose concentration. Water allows the user to "zero" the refractometer so fruit juices can be correctly measured. An ideal water source is deionized (DI) or distilled water - water that has been filtered to remove ions such as sodium, calcium, iron and other impurities. In the past, both types of water were available at grocery stores, but are now difficult to find due to production cost. More common now are the many brands of bottled drinking water, which have been filtered using

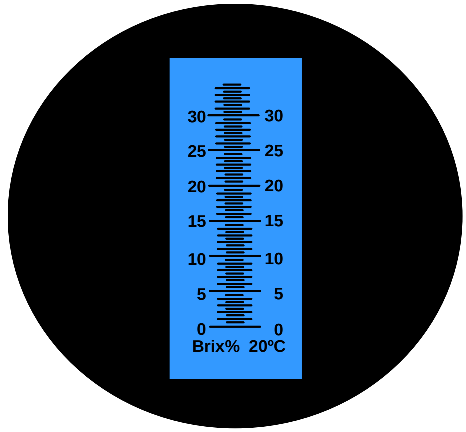

Figure 2. The field of view in an analog refractometer remains blue when only light passes through the prism.

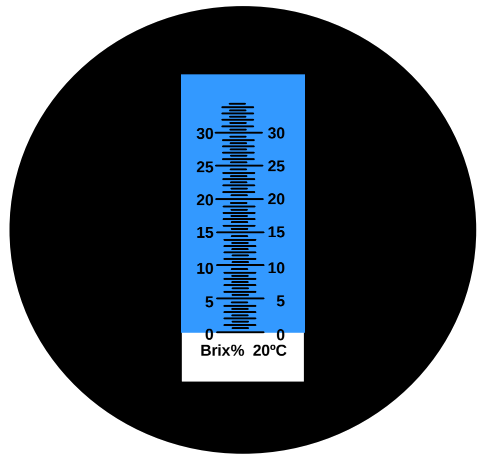

Figure 3. When water is placed on the prism, a contrast line develops at the "0" mark on the scale.

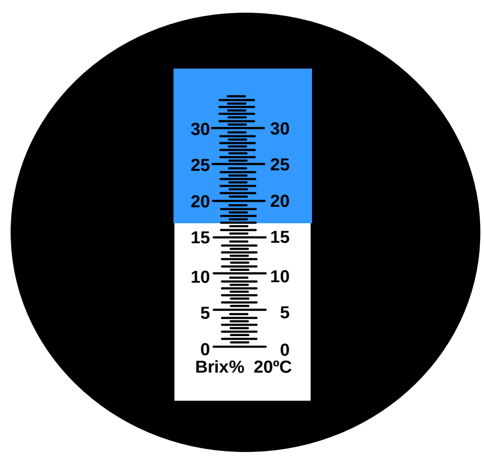

Figure 4. A solution containing sugar will display the percent sucrose in ºBrix units. The sample placed on this prism is displaying 17 ºBrix.

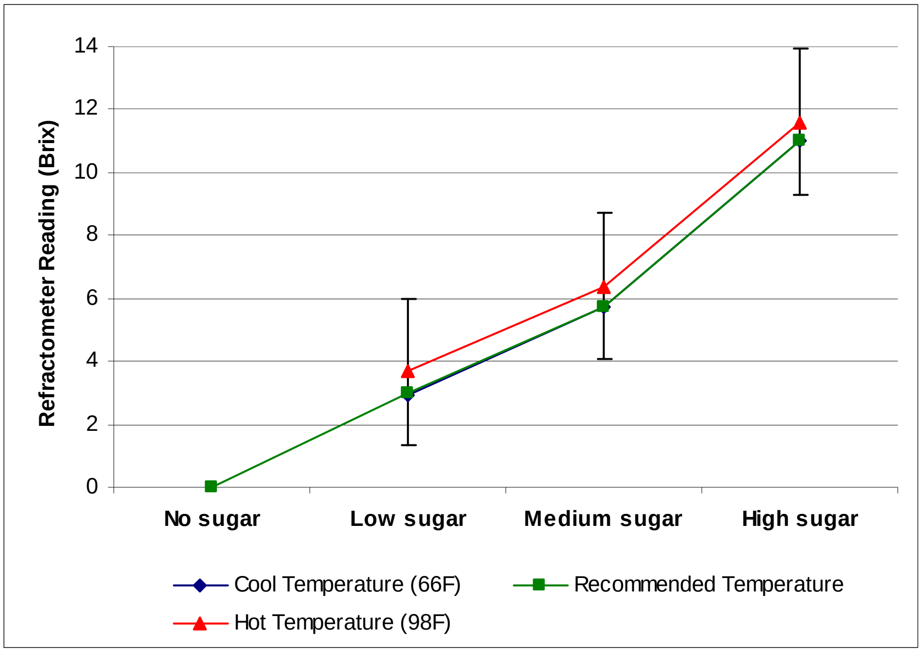

Figure 5. Variability in ºBrix readings as a result of solution temperature. Cool temperatures did not have as great an effect on the readings as hot temperatures. Standard deviations associated with the high temperature readings are presented in the graph.

reverse osmosis to remove impurities. Test solutions are needed to calibrate your refractometer. Kits that include solutions with known ºBrix values can be purchased from refractometer manufacturers, but can be expensive. The following method can be used to make your own calibration test kit, saving yourself hundreds of dollars.

Making a Calibration Test Kit

1. Obtain the following materials (Fig. 6).
   a. 4 bottles of drinking water containing 500ml (16.9 fl oz) each.
   b. A 100-count box of sugar packets with each packet containing 3 grams of sugar. The amount of sugar is specified on the box where nutrition information is listed.
   c. Felt tip marker.
   d. TC or ATC refractometer.
   e. A clean, soft, lint-free cloth.
2. Carefully remove 5 capfuls of water from each bottle to allow room for the addition of sugar.
3. Clearly label each bottle with one of the following designations: 0, 5, 10, 20. *Marking the bottle and cap using a permanent marker will maintain the identity of the bottle contents.* Count out the correct number of sugar packets and place them in front of the bottle with the corresponding number.
4. Hold the sugar packets up to the light to make sure contents are uniform. Although the box may indicate that each sugar packet contains 3 grams of sugar, we found there was a lot of variability in the actual weight of the sugar packets (Figs. 7 and 8). Carefully pour the contents of the specified number of sugar packets into each bottle. The bottle marked with 5 will receive 5 sugar packets, etc.
5. Secure the cap and vigorously shake each bottle until the sugar is completely dissolved. At the end of this step, four bottles containing 0, 5, 10, and 20 packets of sugar make your calibration test kit.

Steps for Calibration

1. Inspect the refractometer prism for scratches, chips, separations or other aberrations that may interfere with proper readings (Fig. 9). If dusty, rinse with water and wipe with a clean, soft, lint-free cloth.
2. Note the temperature at the time of readings. Most ATC refractometers operate properly in the 68-86ºF range. A laboratory or office at room temperature should be used if outside temperatures exceed the manufacturer's recommended temperature range.
3. Place a few drops of pure water on the prism surface. If it is an analog refractometer, close the cover. If bubbles form, gently pressing the cover will remove the bubbles and help disperse the water over the entire surface. For digital refractometers, make sure that bubbles in the well are eliminated prior to making a reading.

Figure 6. Simple field refractometer calibration test kit.

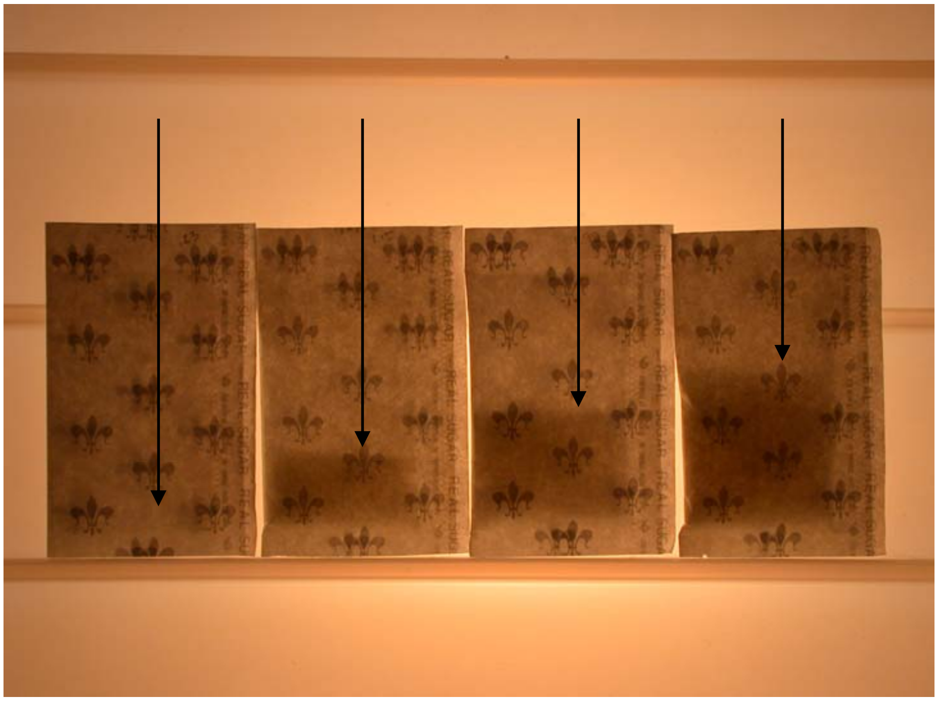

Figure 7. Visual difference in contents of commercial sugar packets. The packet on the far left is empty and the packet on the far right has the expected amount of sugar. Arrows indicate level of sugar in each packet.

4. Hold the refractometer up to natural light or an incandescent bulb to obtain the reading. Looking into the eyepiece, one should see a distinct separation between a blue and white section, often called a "contrast" line. If the contrast line is not directly at zero, then adjust by turning the screw on the top of the refractometer until it reads zero (Fig. 3). Replace the plastic cap after adjusting the calibration screw to prevent water from entering the refractometer. You can adjust the focus by twisting the eyepiece until the scale can be seen clearly. Once the refractometer is calibrated to zero with pure water, dry the surfaces with a clean cloth. Digital refractometers should be calibrated by pressing the zero button with water in the well.

5. Place some of the solution from the 5-packet bottle on the prism and close the cover, making sure that the entire surface is filled and void of bubbles. Note the value and write it in Table 1 under *Your Value*. For digital refractometers, place the solution in the well and press the *start* button. Record the value in Table 1. The value will remain on the LED display until the next sample is read.

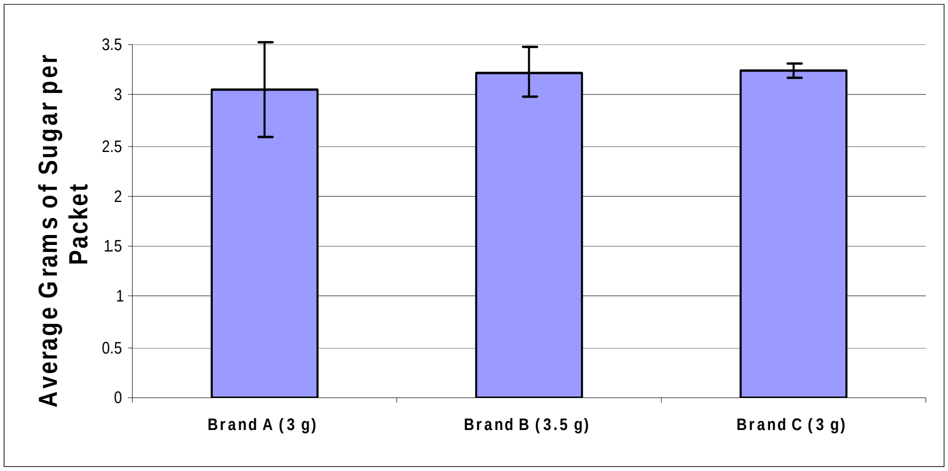

Figure 8. Chart documenting the variability in grams of sugar per packet in commercially packaged sugar. The numbers in parentheses following the Brand designation are the contents specified on the labels. 25 packets of each brand were weighed.

6. Between samples, clean the refractometer prism surface with pure water and wipe dry.

7. Repeat steps 5 and 6 with bottles marked 10 and 20. Record the values in Table 1.

8. Compare your values with those in Table 1. If your values are outside the expected range, follow the calibration steps a second time. If they are still outside the range, read the following "Trouble Shooting" section for help.

Trouble Shooting Tips

1. Check to make sure that the bottled water used was unopened/new.

2. Check to make sure that 500ml water bottles and 3g sugar packets were used.

3. Check to make sure that 5 capfuls of water were removed before adding sugar.

4. Check to make sure that the packets had close to the same amount of sugar in them and that the appropriate number of packets were added to each of the bottles.

Table 1. Simple field refractometer calibration test kit expected values.

Treatment	Average	Standard Deviation	Range*	*Your Value*
0	0.00	0.020	0-0.1	
5-packet	2.99	0.108	2.8-3.4	
10-packet	5.72	0.262	5.0-6.0	
20-packet	11.04	0.260	10.6-11.8	

*** Refractometers are accurate ±0.2% when used under normal conditions.**

5. Check to see if the refractometer is temperature compensating. If it is not, a corrections table is needed to make adjustments. The corrections table is only valid if the temperature was recorded for each reading.

6. Check to make sure that an ATC refractometer was used within its range of 68-86ºF.

7. Check to make sure that the solution is within the temperature range of the ATC refractometer.

8. Replace the batteries in the digital refractometer at the beginning of each season.

Maintenance

Refractometers are analytical instruments that must be properly maintained for accurate readings. Here are some simple tips to assure accurate readings from season to season.

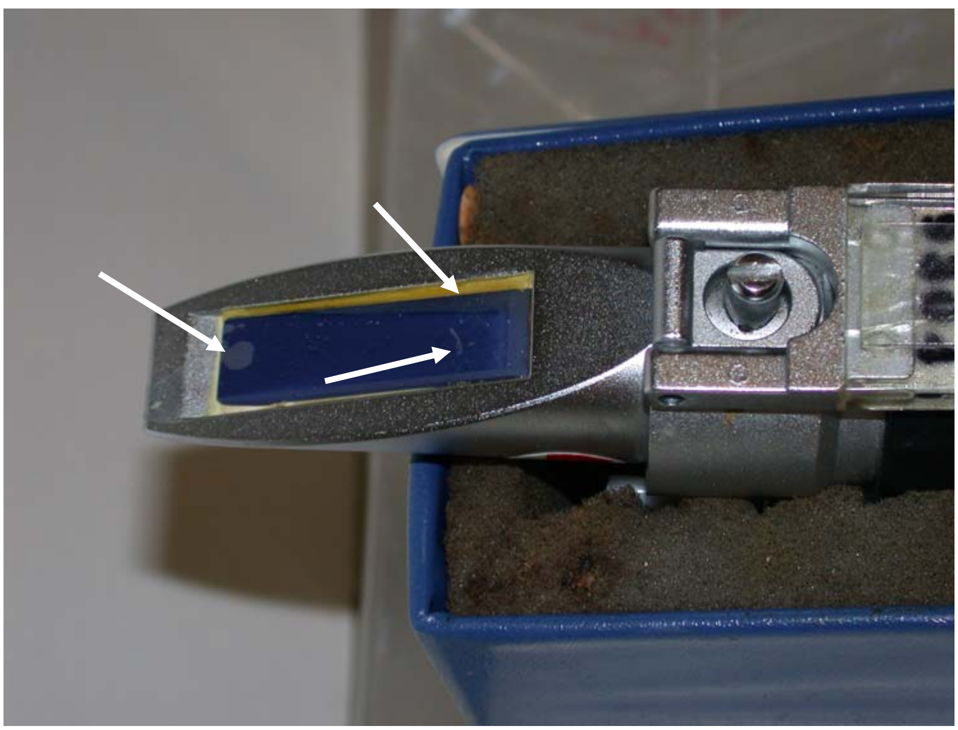

Figure 9. Poorly maintained refractometer with a damaged prism. Scratches, separations, and detached prism noted by arrows.

Refractometers should not be exposed to wet environments. After each reading or before storing the refractometer, the prism should be thoroughly cleaned with water and dried.

If the field of view in an analog refractometer becomes cloudy, it most likely has been immersed in water and can only be fixed by a professional technician. Exposing a digital refractometer to excess water may damage the internal electronics.

Do not evaluate solutions that the refractometer is not made for. If your goal is to read sugar samples, do not try to measure saline solutions. Doing so will compromise the instrument. Purchase a refractometer made for the solution you are interested in evaluating.

Handle your refractometer with care. Dropping it can break, scratch, or displace the optics and/or prism.

Store your refractometer in a location that has a constant temperature. Storing it in a location that has more than a 5ºF difference each day will severely compromise the optics and prism.

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