"Better to get hurt by the truth than comforted with a lie."

— Khaled Hosseini

Last month I explained the mechanics of extracting honey (see July 2020's "Extracting, Step by Step"). One of the elements I emphasized is the importance of using a refractometer to ensure that the honey you are storing away doesn't have a too-high moisture content which could lead to it fermenting into a nasty bucket of goo. People who haven't encountered this problem often joke that they then would have mead, but that's like saying that we can leave a gallon jug of milk out on the back porch for a couple of months and end up with a nice block of delicious cheddar cheese. It just doesn't work that way.

A refractometer measures the extent that light bends when it moves from the air into a substance. The measurement is called the Refractive Index. Dissolved sugar substantially changes the Refractive Index of water. A refractometer allows us to assess the percent of water versus solids (sugar) in our honey.

Refractometers are used in a wide variety of applications. Perhaps they are most commonly used to suss out a small fraction of solids in a liquid, such as in winemaking and salt water aquarium maintenance. However, for honey, we must have a device that is calibrated not for "lots of water and a few solids", but instead for "lots of solids and a little water". When buying a refractometer, be extremely careful to purchase the right kind – i.e., one that is calibrated for honey! Also be careful that the calibration instructions that are included with the refractometer are valid for honey-calibrated devices. Sometimes the wrong instructions (appropriate for high moisture) are included with the correct devices (appropriate for low moisture), leaving their owners very confused!

Easy Peasy

An optical refractometer, the kind used by most beekeepers, has an eyepiece, similar to one on a microscope or binoculars. This is attached to a slanted prism. On top of the prism

An inexpensive hand-held optical refractometer belongs in every hobbyist beekeeper's toolbox.

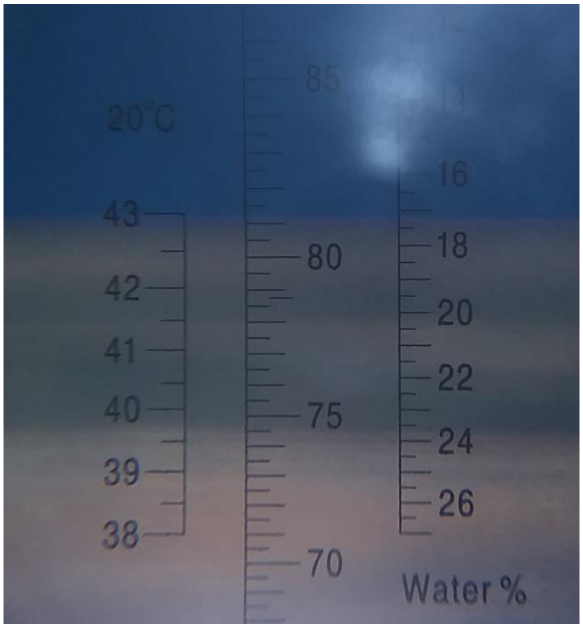
is a hinged cover. To use a common handheld refractometer, just open the hinged cover plate. Place a couple of drops of honey – enough to get good coverage – on the prism surface. Close the plate and press on it to ensure that the honey spreads across the surface. Point the refractometer in the direction of a bright light and look through the eyepiece. You'll see an image that is blue on top and clear below. The border line between the blue field and the clear field is what we are interested in. Adjust the focus by turning the ring on the eyepiece until the numbers are sharp.

There may be several different scales marked in the field of vision. On the scale that is labeled "Water %", read the number that corresponds with the edge of the blue field. We are very happy if the reading shows 18.6% or less.

Once you've taken your reading, open the hinged cover and clean the prism plate with a damp cloth. Do not immerse a refractometer in water!

Challenges

This sounds very simple and direct. However, the challenge is in the details. For example, temperature has an effect on the refractive index of a substance. The devices are originally calibrated assuming the temperature is 20°C (68°F, aka "room temperature"). The refractive index decreases as the temperature



The boundary between the blue section and the clear section is right around 17.1% moisture (the scale on the far right). Hurray! (This photo was taken through the refractometer's eyepiece with my phone so the clarity isn't as sharp as in real life.)

increases, all else equal. The correction formula is $n_D^{20} = n_D^T + 0.00045(T - 20^oC)$.

As an example, assume that we measure a honey sample that is 17.6% water at 20°C; the refractive index is 1.4925. At 30°C (86°F) the unadjusted, apparent reading would be 1.4880, indicating 19.4% water. Our honey has gone from "nicely dry" to "over the threshold – too wet." But not really – it's the same honey! It is the reading that is off.

Many refractometers have Automatic Temperature Compensation (ATC). This helps with the temperature issue described above, but even so, beware if the measurement environment is significantly different than what it was when the device was last calibrated.

Even at "room temperature" and with ATC, a refractometer cannot work properly if the ambient environment, the sample and the device are not all at the same temperature. For example, if we carry our refractometer to our hives in our pants pocket and take it out to sample a frame of honey, it is likely going to be closer to our body temperature than the air is. Give it a little while (about a minute) to adjust. Likewise, give the sample time to adjust to the temperature of the refractometer; let it sit on the prism plate for a few seconds before taking a reading.

Refractive index is also influenced by the wavelength of light that is used to produce the reading. In a laboratory setting, this is an important factor. However hobbyists with handheld refractors will always be using some version of white light and the wavelength won't appreciably vary.

It is worth mentioning that the darker the sample is, the crisper the boundary between the blue and clear fields will be. Very light honey may yield a fuzzier boundary.

Calibration

The way to increase confidence that our readings are reasonably accurate is to calibrate the instrument before using it. This is not much more difficult than taking a normal reading. The only differences are that 1) we test a substance with a known refractive index and 2) we use the little screwdriver supplied with the refractometer to turn an adjustment screw until the blue border lies on the known reference value. The adjustment screw is underneath a little cap on the top of the instrument just in front of the eyepiece.

A universal frustration among refractometer owners is that although the device comes with a vial of calibration fluid, the vial is tiny and there isn't enough fluid in there to drown a gnat. We don't need much at a time, but eventually we run out. Guess what? Official calibration fluid purchased from the original vendor is usually preposterously expensive on a per-ounce basis. But don't worry, any substance that has a similar density as honey can be used to calibrate our refractometer as long as the refractive index for the substance is known and is reliably consistent in all samples.

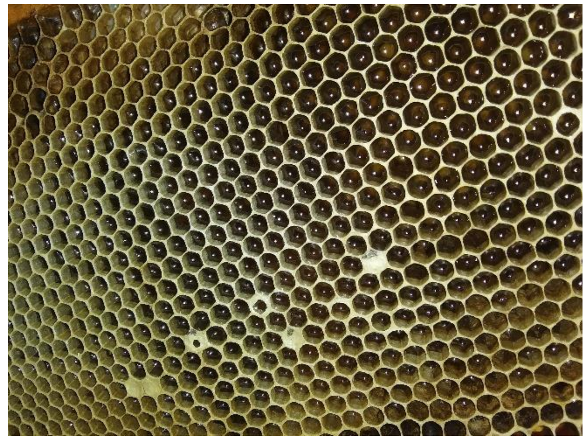
Beekeepers often choose extra-virgin olive oil as a reasonably good calibration fluid. The purity and density are governed by all sorts of olive-industry standards. The reading using the device's Brix Scale should be calibrated to 71.5.

Another alternative for a reference solution is 99.5% anhydrous glycerin, available in the drug store's skin care section, which should have a Brix value of 73.8.

Note that the Brix scale is useful for calibration but the value isn't what we use to accurately and meaningfully report the water content of honey. Each degree on the Brix scale equates to one gram of sucrose in 100 grams of water. For pure sucrose solutions, the percentage of water is 100 minus the Brix value. However, honey is not pure sucrose. It is mostly fructose and glucose, with other miscellaneous sugars etc., and their refractive index is different than sucrose. Therefore the Brix value for honey is not 100 minus the water percentage. It is in the ballpark but not the same. That's why we report the refractometer's "Water %" reading, not the Brix scale value, when we talk about moisture in honey.

To summarize…

- All beekeepers should bite the bullet and get a refractometer. For most of us, an inexpensive hand-held optical model with Automatic Temperature Compensation is precise enough and can be bought for far less than $100. Expensive electronic models are available that are more precise and even simpler to calibrate than optical versions; those cost between $300 and $500.
- To be useful, the readings must be trustworthy. Calibration using a substance that gives a reliable reading is necessary. The fluid that comes with the refractometer is ideal but easily-obtainable fluids such as extra-virgin olive oil are acceptable alternatives. Note that many of these substances tend to absorb moisture, so store the preferred calibration fluid in a tightly-sealed container.
- It is critical that the air, the refractometer and the sample are all the same temperature. Don't rush to take a reading. Give the device and sample time to adjust to the environment.
- Take several samples from the same batch. Honey at the top of a bucket can have a different moisture content than honey in the middle or bottom.



This honey has remained uncapped for a long time. It passes the shake test (described in "Extracting, Step by Step"), but is it truly dry enough to harvest? If it is too wet it can mess up the rest of the batch. But a full medium frame of honey is worth $40 to $60 at premium retail in the Triangle, too much to waste if it is okay. Where's my refractometer?

It is much better to test our honey and discover whether it is at risk of fermentation than to assume that it isn't and be wrong. Hopefully these tips will help you to confidently do so!

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