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Measuring Coffee Bean Moisture Content

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Why measure coffee bean moisture content?

The amount of moisture in coffee parchment and beans is important for two reasons: (1) coffee that is too high or too low in moisture will not maintain high cupping quality, and (2) you are trading in coffee, not water.

Green coffee that is high in moisture (greater than 12 percent wet basis) can deteriorate due to bacteria, mold, or yeast, especially if the seed is killed. If the seed remains alive, enzymatic activity will cause the cupping quality to change. In any case, the parchment coffee moisture level should be lowered to below 12 percent soon after harvest.

When the ambient relative humidity is about 70 percent, coffee beans will gradually equilibrate to about 12 percent moisture. Thus green bean coffee is generally dried to 12 percent, and bought and sold at this moisture percentage. If the bean dries to below 9 percent moisture, it will shrink enough to become distorted, which will give the appearance of low-quality coffee.

To meet the Hawai'i Department of Agriculture standards for coffee (see www.hawaiiag.org/hdoa/admin-rules.htm), the moisture level must be between 9 and 12 percent, ± 0.3 percentage points.

Coffee of consistent quality commands a higher price. The range for maintaining quality is quite broad, making it easier to know the coffee is at the correct moisture. Precisely knowing the coffee is at 12 percent moisture is not necessary except in the market. Knowing the coffee is between 12 and 9 percent moisture at all times after it is dried is important to ensuring that your coffee has the best quality at the time of sale.

A deviation of one percentage point from 12 percent moisture content represents 1 pound of water per 100-lb bag; at 11 percent moisture, you need an extra pound of coffee to make the 100 pounds. Depending on the number of bags and the price of coffee, not knowing the correct moisture content can lead to quite a bit of money at issue.

How is bean moisture content measured?

Oven (standard method)

The internationally accepted standard method for determining moisture in coffee is the loss of weight on heating. Although the loss in weight may not be only water, in coffee the other volatiles are not significant when using the standard drying time and temperature.

For this method, you should have a scale capable of accurately determining the weight of your samples to 1 part in 1000 or better. You also need a hot-box (e.g., an oven) that can maintain a temperature of 220°F (105°C) ± 5°F, with natural airflow, for 24 hours. Airflow should not be overly restricted. Airflow is needed to carry off the moisture.

A convenient sample size is 100 g initial weight. The samples are placed in the oven at 220°F for 24 hours. They are then weighed again (final weight). The difference between the initial weight and the final weight is the water, and it is also the percent moisture in the sample if you started with 100 grams. If you use a different initial weight, you will have to divide the difference in weight by the initial weight to get the percent moisture. (If 10 oz, the percent is obtained by multiplying the difference by 10.)

You should not need to use this method (oven drying) very often. It should be used only when you suspect another method has drifted off calibration.

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Brittleness of parchment

The hull on parchment becomes brittle as it dries. When you can easily crumble the hull in your hand the parchment is dry under normal drying conditions. The bean may still be on the high side of 12 percent. When the coffee is drying, the hull will be drier than the bean; in storage, the bean will be drier than the hull.

Use hull brittleness only as a very rough indicator of bean moisture. The bean can still be quite wet when the hull is brittle, and it could mold in storage.

Color

Coffee beans at 12 percent moisture are a rich green with a slight translucence. Wet coffee or coffee that has been rewetted and redried is more opaque and whiter. There is little change in color until moisture drops well below 12 percent, but the beans will tend to become distorted.

Although there may be a few individuals that can, with much experience, judge moisture by color, a mistake is expensive. A bag of molded green bean would be a bigger loss than the cost of a moisture meter. Use color only as a rough guide—if the beans are not a rich green color, they are not dry, or they have some other problem. It is best to check the moisture with a reliable meter.

Hardness of bean

A bean fresh from demucilaging, whether through fermentation or mechanical means, will be at 45–55 percent moisture. Removing the hull is not easy, and the bean inside is rubbery. If you bite on it, it will be about "al dente," in the sense that the term is applied to spaghetti. As the bean dries, it will get harder. At 12 percent it will be quite hard and will crack rather than shear or dent when you bite it. The hardness may be slightly different under different growing conditions, but we have not done any research to show this.

Combining color and hardness observations will make a guess at the moisture level better, but it still will be a guess. A reliable meter is not that expensive compared to the mistake you could easily make.

Electronic meters

Moisture content affects the electrical properties of materials. These properties include the inductance, resistance, and capacitance of the sample. The electrical characteristics also change with the temperature, density, and chemical make-up of the sample. This is why a good moisture meter measures density and temperature as well as the electrical characteristics. Chemical make-up is accounted for by using a different calibration curve for different commodities.

Repeatability is perhaps the most important characteristic of a meter. You should get approximately the same reading for a sample if it is presented (poured out and put back in) several times. The variability of readings from a sample presented several times to the meter (repeatability) is the real accuracy of the meter and cannot be eliminated by calibration. A meter can be made more precise by taking the average of the same sample presented multiple times.

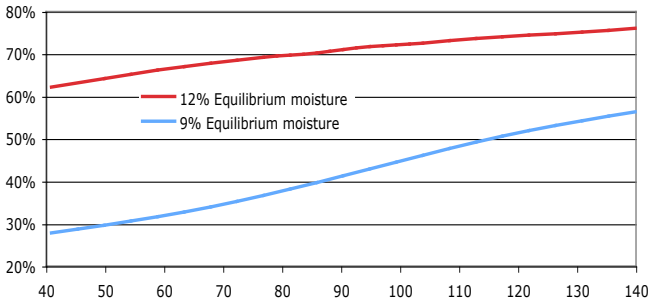
Moisture meters that measure inductance are rare. In general, measuring electrical inductance is difficult and usually expensive, although this is changing with advances in electronics.

Measuring electrical resistance is easy and inexpensive. The sample of beans may be placed in a container, with two electrodes in contact the beans. Sometimes the electrodes are like needles and can be inserted into a bag. The problem with using resistance measurements with coffee is the same as with all granular materials: the electrical path is inconsistent, depending on the pressure on the sample and the placement of the grains relative to each other. Most resistance moisture meters are not very accurate because making the measurement repeatable is difficult.

The most-used moisture meters for coffee are adapted grain meters that measure capacitance. An electrical capacitor consists of two plates separated by some insulating material. The rate that an electrical charge can be built up on the capacitor depends on the material between the plates, if nothing else changes. The material can be air or coffee, among other things. Temperature, bulk density, and moisture content of the coffee determine how it acts as a dielectric, or capacitor separation material.

Modern capacitance moisture meters measure temperature, bulk density, and capacitance. Some use a cup with a cone inside it to hold the sample; the outside of the cup is one "plate" of the capacitor, and the inside cone is the other. A temperature sensor is located in the cup. The volume of the cup is fixed, and the meter weighs the cup. Filling the cup evenly and consistently is handled in different ways. Some meters sense the fill rate and flash a warning. Others use funnels with snap doors. Using an internal microprocessor, the meter calculates the moisture content according to a calibration curve for the particular material.

Relationship of relative humidity to temperature (°F) for coffee at two moisture contents



Calibration

Of the methods for measuring moisture listed above, only the oven method does not need calibration and as such is a convenient reference method.

Any electronic device will change with time. This drift can be corrected by calibration against a reference method such as oven drying (best), or a certified meter calibrated with a reference method. A meter that needs frequent recalibration should be sent for repair or replaced.

A meter that is not repeatable cannot be simply calibrated to increase accuracy. It will need repair. Accuracy may be increased using the average of multiple measurements, but this is time-consuming and relies on the meter error being random with a mean of zero. If the meter error is not random with a mean of zero, taking the average of multiple measurements will simply give you a precise value of an inaccurate measurement.

Any meter that says the coffee is near 12 percent when the bean is whitish and/or soft should be calibrated.

When to measure moisture?

Near the end of drying

There really is no need to check the moisture of beans with a meter until they start to get hard. If you are using a forced-, heated-air dryer, you will want to make sure you don't get the beans too dry. You will need to measure the moisture content frequently as it approaches 12 percent. Let the coffee cool to ambient temperature unless the meter has high-temperature capability.

During storage

The storage should be in the range of 60–70 percent relative humidity (RH). Remember that the relative humidity increases as the temperature goes down, so set your storage RH to 70 percent at the lowest expected temperature (see figure). It is best to store the coffee as parchment.

If your storage maintains a constant temperature and humidity, check the moisture of your coffee once a month during storage to assure yourself everything is okay. If you are not controlling the storage air conditions, check it more frequently. You want to know that the bean moisture is at 12 percent when you are ready to sell or roast the coffee.

Where to measure moisture?

At the mill

Any dry mill dealing with substantial quantities of coffee should have a moisture meter that is repeatable (gives the same reading for the same sample every time). State regulations say that any meter used in trade must be certified. If such a meter is calibrated, it will be accurate. It is reassuring to verify what the mill's meter says, so you may want to do your own moisture determination at the farm.

On the farm

If you are selling roasted coffee and doing your own roasting, the moisture of the coffee at the beginning of the roast should be uniform, but it can be anywhere between 9 and 12 percent. Your work will be a lot easier if you always start with the same moisture content. If the starting moisture varies, your roasting protocol will have to be adjusted to compensate.

If you are drying or storing coffee or selling green bean, you should use a moisture meter at the farm. Make sure that the meter is calibrated at 12 percent and gives the same value over time. Accuracy above or below 12 percent is not necessary unless you are making adjustments in a business trade.