Green Coffee Analytics: Relevance to Roasters, Buyers, and Producers
Part I: Total Moisture Content and Water Activity
By Chris Kornman, May 2016

Most coffee professionals on the buying, roasting, and brewing side of the industry understand and value sensory analysis of coffee. Cupping a coffee, after all, is the single most common and effective way to decide if a coffee is worth purchasing, or if a roast has succeeded or failed. Scores and notes help organize inventories, determine usage, and even provide feedback to producers. In many cases, these scores are even tied to real dollar value whether as green or roasted product.

I’d wager that most of the community have at least a cursory knowledge of green grading as well, but I suspect that for many buyers and roasters it’s an afterthought or a metric that is applied haphazardly at best, with little connection to what we usually think of when we think of “quality.” In light of this, I’d like to outline a number of different measurements and describe how they can add value across the supply chain. The first part of this series will focus on moisture in green coffee.
Total Moisture Content

Moisture content has been a defining characteristic of the coffee export trade for eons. The figure 12% is tossed around fairly loosely, frequently eliciting rejections once it is exceeded. Likewise, the measurement of water activity has become an increasingly common interjection to conversations about physical quality, though its limits are a little less universally acknowledged. Let’s dig into what these two different measurements mean, how they are related to each other, and how they can be used as quality tools for the specialty roaster, buyer, and grower.

Moisture content is defined as water bound up inside the coffee seed. When a coffee cherry is picked, the seed is full of water and must be dried before export. Throughout the world, this is accomplished in a variety of ways with varying effects on the final product. The specialty community has frequently expressed aversion to vertical driers and cylindrical drum *guardiolas* used to mechanically dry coffee across much of Central America and Brazil. Compared to sun-drying on patios or raised beds, the argument goes, mechanical drying is inferior. However, the precision of a well-maintained dryer can improve the producer’s ability to consistently dry large quantities of coffee when the temperature is appropriately monitored. Natural challenges arise for any sun-dried coffees due to the simple nature of exposure to the elements. In my experience, partial shade, protection from rain, and air circulation (frequent parchment turning and/or raised beds) go a long way to ensure that a coffee is appropriately stabilized in sun-dried environments.

It’s generally accepted that drying coffee is the most critical post-harvest processing step, and that in general lower drying temperatures are better at preserving quality.¹ A research team led by respected coffee scientist Dr. Flávio Borém used SCAA style qualitative analysis to confirm physical measurements of numerous phenomena. Among the measurable data they gathered was the ‘leaching’ of potassium from the coffee bean². This is relevant because it illustrates an important point: compounds that are bound up inside green coffee are susceptible to escape and degradation, particularly if damage to the seed occurs during the drying process. This means that quality can escape from green coffee even as it rests on a shelf. Unfortunately, simply taking a moisture content reading cannot give us a sufficient glimpse of this sort of data.

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¹ From one of the most respected voices in coffee research: Flávio Borém, et al., 2008
² Potassium leaching has been correlated to defective quality in green coffee: Marcelo Ribeiro Malta, et al., 1981.
Water Activity

This point brings us to water activity. Humidity, and specifically the evaporation of moisture, is the vehicle by which quality has the potential to escape from green coffee. We can obtain a better indication of the integrity of the structure of the green coffee, and its ability to retain moisture and volatile aromatic compounds, by measuring water activity.

Very briefly, water activity (or $a_w$) is the measurement of vapor pressure or “water energy.” It is expressed mathematically as a comparison of the measurement of the vapor pressure of a substance in question divided by the vapor pressure of water. Imagine the same amount of water is added to two glasses: one with a sponge and one without. The water will evaporate more slowly from the glass with the sponge, because the moisture is bound up in parts of that sponge. So, any substance will have less water activity than water alone, because the moisture in that substance will be bound up in varying degrees. As a result, water activity measurements are expressed as a decimal; a water activity measurement of coffee will always be expressed as a numerical value less than one but greater than zero. Water activity readings may vary in reliability depending on the type of device in use, and these readings can be affected by temperature, relative humidity, and other ambient environmental conditions.

The use of water activity measurements as a food safety indicator has been in circulation since the middle of the 20th century. William James Scott was able to convincingly prove that water activity measurements can predict microbial growth in 1953. Since that time, water activity has come to be accepted as a more accurate and important indicator of “microbial, chemical, and physical properties... than is total moisture content.”

Across many industries water activity measurement is now considered vital not just for safety, but as an indicator of potential for chemical and physical reactions.

As you might imagine, this is relevant to coffee in a number of ways. The first and most obvious is in product safety. At a certain level, mold and other microbes can grow; that level is firmly established across all substance types. Below a water activity range of 0.60, no microbial proliferation occurs, and foods are generally considered free from potential for new contamination. Between the range of 0.60 and 0.90 $a_w$, molds and other fungi, yeasts, and other microbial activity increases, particularly at higher ranges. Of particular interest to coffee are mold types that contain mycotoxins and

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3 Jorge Chirife and Anthony J. Fontana, Jr., 2007
4 Anthony J. Fontana, Jr., 2008
ochratoxins, as these are known hazards to health. Per AquaLab water activity “for molds and yeast growth is about 0.61 with the lower limit for growth of mycotoxigenic molds at 0.78 a_w.”

During post-harvest processing, HACCP guidelines suggest that “all coffee, cherry or parchment, must spend no more than four days between [water activity of] 0.95… and… 0.80.” It’s a little hard to imagine a farmer or producer measuring the water activity of their coffee while it ferments, or during the first few days on a patio or drying table. If you think about it, however, these are some things we’ve felt intuitively and know experientially. Wet parchment sitting around in bags in Sumatra, for example, generally isn’t a favorable storage condition for coffee of any quality. Similarly, Rwandan and Brazilian practice of tarp coverings for wet parchment coffee on beds or patios can foster microbial growth (the spread of potato through a lot, or the off flavors of rio/phenol, respectively).

In terms of practical applications for the coffee roaster and buyer, AquaLab has some relevant points to make: “Green coffee deteriorates very gradually, but the ‘past crop’ taste… is partially associated with the hydrolysis of sucrose into glucose, especially. Higher water activity can possibly provide an indication of the level of this activity.”

Put simply, water activity measurements can help indicate the shelf-stability of a coffee, particularly as it relates to perceived past crop flavors. These flavors are related to the escape and/or chemical change in compounds created inside the bean and preserved (or not) by the drying process post-harvest. While it’s impossible to predict an exact shelf-life using water activity readings, we can use water activity to give us an indication of how well-dried, and thus how stable a green coffee might be. When used in conjunction with moisture content, this can be a powerful tool for evaluating the longevity of a high-dollar/high quality product’s value. For

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5 AquaLab is the water activity meter manufacturing arm of Decagon. They have numerous product manuals and educational resources available for free online, including the one quoted here: [http://agrotheque.free.fr/Fundamentals.pdf](http://agrotheque.free.fr/Fundamentals.pdf)
6 Hazard Analysis and Critical Control Points, as recommended by the FDA & USDA
7 This HACCP guideline is quoted by Aqualab [here](http://agrotheque.free.fr/Fundamentals.pdf).
8 Again, Aqualab’s [Coffee product manual](http://agrotheque.free.fr/Fundamentals.pdf) is responsible for this claim.
9 [Theodore P. Labuza, 1980](http://agrotheque.free.fr/Fundamentals.pdf)
most purposes, the upper limit of 0.60 seems like a convenient “soft” limit for predicting shelf stability for more than 6 months past harvest under normal storage conditions (moderate temperatures, low relative humidity, GrainPro or other preservation method also recommended to help prevent moisture migration).

There’s yet another side to this coin: water activity has the ability to predict the potential and rate of changes related to browning reactions like caramelization and Maillard reactions. We know that these reactions are absolutely critical to the development of complex chain sugars and aromatic compounds and flavors in coffee as it roasts. Maillard reaction rate increases in conjunction with water activity, reaching maximum potential at between 0.60 and 0.70, with increases beyond 0.70 generally decreasing likelihood again.¹⁰

So, let’s look at this on a basic chart that should help frame the discussion visually:

You can see that the range for shelf stability is a little lower than the peak for browning reactions, and that the microbial activity potential increases beyond 0.60. In light of these signposts, coffee’s ideal water activity could be described as “close to 0.60.” Each roaster and buyer, however, must choose on which side of this line they prefer to err: higher than 0.60.

¹⁰ [http://www.webpal.org/SAFE/aaarecovery/2_food_storage/Processing/Water%20Activity.pdf](http://www.webpal.org/SAFE/aaarecovery/2_food_storage/Processing/Water%20Activity.pdf)
increases rate of browning reactions like Maillard and caramelization, but also increases both
the risk of safety and stability. A coffee with a water activity around 0.63 may taste great three
months after harvest, but may fade more rapidly than a coffee with a water activity of 0.57.

While data on the relationship of water activity to specific coffee traits (country of origin, variety,
drying method) must still be gathered to make data-based inferences, it's safe to suggest a few
extrapolations based on common sense and the critical role of post-harvest drying. For
example, because natural-dry (or cherry-dried) process coffees tend to rely heavily on fruit
sugars rather than caramelization for their characteristic sweetness, and because these coffees
often dry in large piles which can promote inconsistency and infections, it's likely that the buyer
of such a coffee would prefer lower water activity readings than a fully washed lot which was
harvested under similar conditions. Similarly, a fully washed and raised-bed dried coffee,
produced under the watchful care of attentive producers (who may do things like frequently
turning the drying parchment and/or using shade to prevent over-drying or parchment cracking)
will likely suffer less from stability issues long after harvest, even if the water activity is a little
high. However, in most cases, stable coffees with ideal moisture content indicate good drying
practices which have sufficiently preserved the integrity of cellular structures to retain
compounds that contribute to high quality flavors. Conversely, water activity readings that are
either too low or too high can often indicate that those cellular structures were in some way
compromised, almost certainly during the drying process. As with most types of data
interpretation, more work must be done in this field to draw more precise conclusions.

There’s a point here that bears repeating: while there are hard lines for safety, and relatively
well-understood limits for shelf stability and browning reactions, there is not a truly “ideal”
reading for a particular green coffee’s water activity. Instead, this reading should be used as a
tool to help us understand the complexities at play in coffee, and to balance risk/reward when
making purchasing decisions.
Summary

Coffee and water are both very complex subjects. Bringing the two together naturally makes discussion complicated. Let’s recap some of the finer points:

- The drying process is the most critical step in quality preservation for coffee post-harvest.
- Moisture content measurement is helpful, but it can only tell you how much water is bound inside the coffee at a given time, unrelated to how stable that water (and therefore, how stable
- the coffee in question) might be.
- Water activity can help predict product safety, shelf stability, and browning reactions.
- The practical application of these data points is relative to the needs and desires of coffee roasters and buyers.
- These measurements can be used to indicate the quality of post-harvest drying.

I should note that my role with Royal Coffee at the Crown has included weekly analysis of total moisture content and water activity, as well as other physical traits of coffees that relate to roasting and beverage quality. Take a peek at a few recent analyses like this dry-process Brazil, this wet-hulled Sumatra (shown below as a screenshot) or this fully washed Guatemala.

Feel free to reach out to me with questions (ckornman@royalcoffee.com), though it should be said I don’t have all the answers. The second part of this series on Green Coffee Analytics will focus on defects, screen size, and specifically density’s relationship to moisture and to roasting.