This week we’re back on the grading table, this time focusing our attention on visual defects in green coffee. In many ways, green coffee defects share some similarities with screen size. They both impact the way a coffee roasts and tastes, and equally can have financial ramifications in terms of contract approvals and value of a given lot.

Methods of Grading and Removal

Also, much like screen size, defect count standards vary significantly from grader to grader. The two most familiar to most graders will be the SCAA format and the Brazil/New York method. Using 300g of green coffee, a grader will pick and categorize different defects. The SCAA has identified category 1 (severe) and category 2 (allowable, less severe) defects, while the Brazil/New York method differentiates between intrinsic defects (like insect damage or shells) and foreign defects (categorizing differences between different sized sticks and stones). You can find a list of the details on both of these defect grading methods here. Obviously, there’s merit to both of these methods, with the SCAA placing a heavier emphasis on flavor impact and the Brazil/New York method helping to secure contracts and protect equipment.
There are a few main sorting methods for defect removal. Hand-removal, either while drying in parchment or after hulling is quite common in many coffee producing countries, particularly in areas with either a long tradition of coffee production or inexpensive labor. Talented individuals can clean about 1 x 60kg bag of coffee per day. In some cases, a conveyer belt will pass coffee along a table of workers to help keep a steady production pace. Automated dry-mill removal typically involves two types of machines. A density table separates foreign objects, chipped pieces, and low density coffee from the good stuff by vibrating at a particular angle and frequency. Optical color sorters are becoming increasingly sophisticated, and use laser and other computer-driven technology to remove discolored coffee within a specified tolerance. The best of these machines are remarkably customizable down to the shade of discoloration and amount allowed per bag. While some of the priciest high capacity units could set you back over $100,000, a machine can also process hundreds of bags in a day.

Let's take a quick start-to-finish tour of the cause and effect of some common green coffee flaws. The pictures you see below were meticulously collected and cataloged by our QC and Certifications specialist Rosi Quiñones and documented by our Creative Director Evan Gilman.

**Pre-processing defects**

The main culprits of damage to the coffee while on the tree or immediately after picking are insects, genetic flaws, disease, environmental factors, or human error. Insects, like the coffee berry borer, will literally burrow directly into the seed leaving small visible holes. Discolored coffee, often black or brown in color, can result from a number of different factors, most of which occur before the fruit is stripped away. Frost damage can blacken the seed, as can
insects like the mealy bug or antestia bug, fungi like Coffee Berry Disease and other afflictions, and even nutritional deficiencies, overripe cherries, or delays before depulping. Withered, wrinkled, low density coffee is often the result of drought.

Among the more reviled pre-processing defects are quakers – coffee seeds that don’t properly react during the Maillard stage of roasting. Even at a relatively dark roast, quakers will stand out with their pale orange or khaki appearance, and when ground emit a rancid toasted peanut aroma. These pesky defects are acknowledged to be predominantly the result of underripe coffee. Underripe green seeds will often curl at the edges giving them a “boat-shaped” appearance. While it’s possible to eliminate some underdeveloped seeds in floatation tanks prior to pulping or in grading channels after fermentation, it’s far more effective to remove underripe cherries while it is visibly apparent, before processing begins. Otherwise, the roaster must resort to manual removal post-roast.

There are a few factors that complicate the presence of quakers in coffee. Most high level specialty coffee producers will ensure hand-sorting prior to processing, but government regulations or local traditions can interfere. However, Costa Rican wet mills, as an example, struggle to incentivize high quality picking due to rules that demand they pay the same to all contributing farmers regardless of minor qualitative differences in delivery. (As an aside, this is a problem limited neither to quakers nor Costa Rica: cooperatives and private delivery stations alike grapple with paying fairly and encouraging excellent quality. Whether paying by weight or by volume, there’s often little reason to sort more than the bare minimum without some type of incentive. Uneven distribution of benefits, even when merited by qualitative harvest differences, can cause rifts in community members, however, who may be disadvantaged.
compared to their neighbors due to poor soil or elevation. There’s no easy answer, and it makes getting “perfect” coffee complicated.

Additionally, one tends to find more quakers in coffees that are dried in the cherry (aka ‘natural’ or dry-process) as opposed to those which are depulped, fermented, and washed prior to drying in parchment. Some may argue this is a testament to the success of the washing process removing “floaters” from high grade coffee. Equally as likely is that high value washed coffees tend to have better ripe cherry selection, to begin with, than their lower valued counterparts which are minimally processed and dried in the fruit.

Oh, and there’s another point of confusion for graders: quakers are only identifiable once the coffee has been roasted, and not all green coffee identified as an underripe may result in a quaker. Conversely not all quakers may be readily identifiable as underripe in prepped exportable green coffee. To this effect, CQI and SCAA differ in their approach to the problem: SCAA recognizes underripes as an allowable secondary defect in small quantities, but CQI defines specialty coffee with zero-tolerance for quakers.

Flavor attributes attributed to quakers and underripe coffee tend to differ, as well. A single quaker may taint a sample and create inconsistencies from cup to cup on an evaluation table and elicit notes ranging from peanut or peanut skin to fatty or oily. However, underripe has been classically defined at the cupping table as harsh or rough, generally referring to an astringency accompanied by a fresh hay-like or grassy flavor.

The solution to the problem is singular, however: eliminate underripe coffee cherries from the lot prior to processing and/or drying. (If you’d like to read a little more on quakers, Andi Trindle had an informative article published in Roast Magazine a while back).

Aside from quakers, arguably the most common pre-processing flaws in green coffee tend to be genetic development defects. Genetic flaws take the form of peaberries, shells (sometimes called “elephant ears”), and triangular seeds. It’s possible that the variety of coffee may have
an effect on the frequency of genetic flaws. Anecdotally, I've noticed that SL-28 and SL-34 coffees (most frequently grown in Kenya) tend to have a higher probability of containing shells. In the field, it’s occasionally theorized that genetic flaws in green coffee might be exacerbated by nutritional anomalies like the presence of too much phosphorus in the soil or in applications, for example.

The peaberry (referred to as *caracol* in Latin America) as mentioned above, is generally recognized to be a developmental anomaly that results in the presence of a single seed inside the cherry, rather than two. Most producers will quote the average yield of around 5% of a typical variety Arabica harvest as being peaberry, though I've seen some outliers. The Lublinkhof family in Southern Zambia has an unusually high occurrence of peaberries, up to 20% in some harvests, that could be attributed to a combination of factors including low elevation, arid conditions, and heavy fertilizer application.

Peaberries garner an unprecedented amount of attention in certain regions of the coffee trading world. Anyone who’s ever had a coffee from Tanzania has probably consumed it as a peaberry. Perhaps this has to do with peaberries naturally higher density, which may make the coffee more resistant to fading during transit, which has traditionally been an unfortunate risk in Tanzania. (The hot, humid climate at the main port city of Dar es Salaam is not friendly to the coffee, and delays are common for a myriad of reasons including poor road conditions, disastrously complicated and/or corrupt bureaucratic hurdles, and an internal auction system that sometimes seems to incentivize holding coffee rather than selling it.)

The affection for the funny round little seeds might simply be visual appeal – they're adorable and often pleasantly uniform both before and after roasting. It’s possible, but generally disputed, that peaberries may have more concentrated flavor. They most definitely present challenges in drying and roasting, as their shape, size, and density don’t absorb heat in the same manner as a flat bean.

Coffee typically produces two seeds per cherry, and if the peaberry is the single-seed iteration, triangular seeds and shells represent the other side of the genetic defect coin. Triangles are caused by an extra seed, or multiple extra seeds – in extreme cases I’ve seen images of eight or more seeds per cherry. Much like the peaberry, triangles will roast differently from their more commonly shaped counterparts.

Shells, perhaps the largest nuisance for the roaster of the genetic flaws we’ve talked about, are the result of a phenomenon known as “false polyembryony,” according to *Jean Nicholas Wintgen’s seminal work on coffee growing, processing, and sustainable production*. (Incidentally, this publication has - among innumerable other useful topics, images, and descriptions - a lovely and highly detailed section on green coffee defects which I’ve found to be thoroughly helpful in the formation of this article.) Polyembryony is simply a term that means multiple embryos developing within a single seed, but so-called “false” polyembryony is the
anomalous occurrence of an abnormal dual-embryo instead of two independent embryos. In either case, the seed presents problems to the roaster because of its low density and propensity to break or separate during hulling. In many cases, properly calibrated density tables and screen sorters at the dry mill can effectively sort out peaberries, triangles, and shells.

**Processing Defects**

Defects that occur during processing are generally the most commonly encountered, and by and large are the result of some combination of human and mechanical errors.

Very frequently chipped and sometimes broken coffee will end up in export grade coffee. Chipping can happen both at the pulper (where the affected area will often become slightly discolored during fermentation) or at the dry mill during parchment hulling. While the discolored area of a pulper-damaged coffee can infrequently lead to a bacterial infection, dry-mill nicked beans are rarely cause for serious concern.

Silver-skin discoloration can occur during fermentation and honey- or cherry-drying, resulting in a reddish hue (sometimes referred to as "foxy") that is only skin-deep and generally has little to no effect on the final flavor (though it may affect the coffee's value due to its unsightly appearance). In some cases this can indicate the presence of dirty water during fermentation or washing, which will have a more pronounced effect on roasting and taste.

Coffee that is improperly hulled or pulped so as to leave full coffee pods (the defect term for the whole, dried cherry), significant portions of the cherry skin, and/or parchment stuck to the seed is a more serious concern, as these conditions can sometimes harbor fungal infections
and will never roast properly. While I wouldn’t recommend the practice (parchment is somewhat more combustible than green coffee), the rare un-hulled sample that shows up in your lab can be fun to roast side-by-side with a hulled version to examine the differences.

A few severe defects are endemic to fully washed coffees, resulting from the additional wet processing they undergo before drying and milling. The washing channels used after depulping and fermentation are a first step in grading coffees, separating ‘floaters’ (which can include underripe seeds, drought affected coffee, and other developmental anomalies that negatively affect cup quality) from sinkers (high-density coffee of good quality). Fermenting coffee can also result in ‘stinkers’ – coffee that has overfermented and emits an acetic or briny aroma and flavor. Frequently this is the result of some combination of delays between picking and processing, dirty fermentation tanks, fermentation times that are too long or too short, or under-agitation of the fermenting mass resulting in pockets of over-ferment in an otherwise unaffected batch.

No matter the processing type, however, the most serious processing defects almost always are drying-related. Post-harvest drying is the most critical stage in quality preservation and management, and errors during this hyper-sensitive process are magnified. Under-dried coffee will be soft, sometimes even pliable, and often darker-green in appearance, while coffee that has had interruptions in drying may appear blotchy. Frequently these coffees will taste musty, swampy, or vegetal... at least until they begin to (rapidly) age and taste like cardboard and burlap. Traditionally these aren’t visual defects that are sorted out by people or machines, despite the severe impact on flavor.
Drying coffee - whether in cherry, as depulped parchment, or wet-hulled green - exists in constant threat of microbial activity. Molds and fungi as well as bacteria and other infections may occur as the wet coffee dries, particularly if it is not turned frequently to promote even drying and good airflow. It's possible to spot some fungus visually, while some microbially damaged coffee remains latent until roasting, like the potato defect. If an infection is particularly bad, brownish spores may appear on the surface of the seeds. Black lights can also used to spot fungus damage... but black lights will return false positives for pulper-nicks, drying anomalies, and other less severe defects.

It's impossible to overstate the importance of even, well-ventilated drying: defects that occur at this stage are not only unpleasant to taste, but they can actually present a real health risk. (Check out my series on Molds & Mycotoxins - part I and part II - to learn more about this specific problem.)

Mechanical dryers, known as guardiolas, were developed as an alternative to labor-intensive and climate-susceptible patio or table drying. When properly loaded, and when temperatures are maintained at relatively low heat, these machines can efficiently turn and dry large quantities of coffee. A maximum operating temperature of 45 – 50 C / 113 – 122 F is a widely acknowledged safe limit. Many studies suggest 35 - 40 C / 95 - 104 F might be the best range, as higher operating temperatures have been shown to damage cellular structure of the coffee and negatively impact cup quality. An untended dryer can easily overdry and even begin to roast the coffee, resulting in “green” coffee that appears pale brown in color and tastes woody and bitter.

**Storage Defects**

Even if a coffee makes it all the way from picking to shipping with no problems, there are risks. Beetles are a notorious pest, chewing their way through dried coffee and reproducing prolifically. Storage insect damage holes tend to be much larger than those from insect damage that occurs in the field from the berry borer. Coffee infested with beetles, or with moths or worms that like to eat the jute bags, while in storage must be quarantined. In some cases freezing or cutting off the oxygen supply by completely sealing off the entire lot is necessary to eradicate the menace.

Poor conditions are the other main culprit of storage-damaged coffee. Hot and humid conditions can exacerbate aging. In particularly wet conditions coffee may re-absorb water and fade in appearance as well as flavor. Black spots can occur if coffee has been poorly dried and pockets of water within the bean rot, and of course mold can develop on the surface of the coffee as well. Stable storage conditions will help prevent these defects easily. Dried coffee, whether in parchment or green, prefers environments at or around 65 F / 18 C with moderately low (40-60%) relative humidity.
As with many of the risks across the supply chain, preventative measures are significantly more effective than after-the-fact fixes. It’s not rocket science - good practices and attention to detail are crucial. A well-oiled feedback loop completes the picture: growers, processors, and millers who communicate well with their exporters, importers, and roasters will have a better understanding of expectations, and of where the gaps in their armor exist and how they can be remedied.