Coffee Grinding

and Its Impact on Brewed Coffee Quality

By Daniel Ephraim

The wonderful taste we have come to enjoy from a superb cup of coffee can easily be taken for granted. The transformation of the coffee cherry to a quality brew is complex and one of the most crucial transformations that takes place in the coffee grinding operation. With this said, let's take a look at two simple truths:

We don't eat roasted coffee beans. We drink the beverage that is produced from those roasted whole beans after they are ground, stored, transported, packaged and, finally, brewed.

We can't improve upon the quality of whole bean coffee once it's roasted. We can only reduce that quality by not optimizing that process from whole bean to beverage. If we were to have roasted whole coffee beans that were a perfect, say, "100" on some qualitative scale, the best that we can hope for in the brewed beverage is a quality level of "100." We cannot hope for a quality level of, say, "105," however, any part of the process from whole bean to beverage can reduce the quality of the whole bean, as reflected in the beverage (brew), to something less than that"100" level.

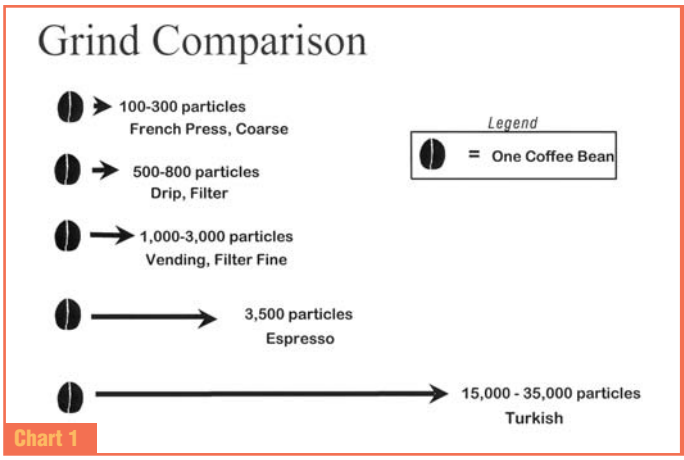

Chart 1

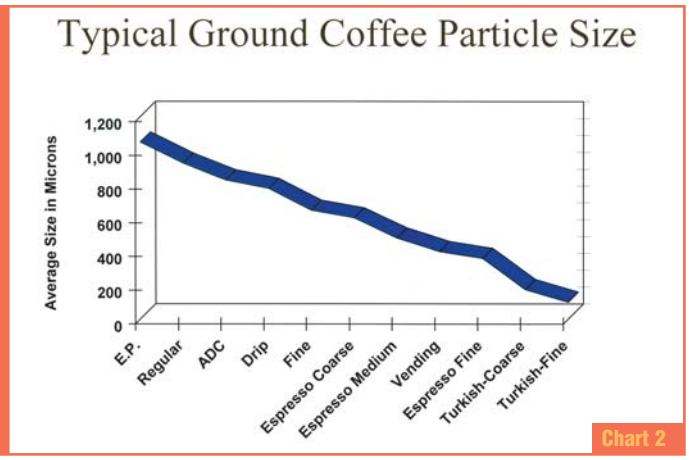

Chart 2

It follows, then, that a most critical part of the transformation process from whole bean to beverage is grinding!

The Two Primary Factors in Coffee Grinding Are:

Particle size; Each brewing method, or technique, has an ideal particle size that optimizes the extraction which occurs utilizing that methodology.

Particle uniformity; Ground coffee particles that are not the ideal size, or outside the target range for a particular brewing methodology, will either over-extract or under-extract the soluble solids and other critical coffee elements from those coffee particles.

Brew quality, then, is directly affected by both matching the target particle size to the method and insuring that the entirety of the grind is as uniformly close to that target as possible.

This sounds pretty straightforward so far, so let's look at how we define particle size. We can look at a single coffee bean and, to try to gain an understanding of what's behind coffee grinding, proceed to break that bean into some number of pieces. If we break it into between 100 and 300 pieces, it may become suitable for a French Press or Urn grind. Break it into a few more pieces, say 500-800, and it's good for a Drip or Filter grind. To achieve a Euro-Fine or Vending grind, we have to grind that one bean into 1000-3000 particles! If we are to achieve an Espresso grind, that bean becomes 3500 particles while Turkish may be as many as 35,000 particles from one bean! (See chart #1)

Wow, there is a lot going on to grind that one bean to the ideal particle size! For instance, if the goal is to produce a filter-fine grind, but we only grind the bean into 300 pieces, well, we're not going to optimize the brewing process or keep that whole bean value at the "100" level.

Before we move on, let's look at how we characterize the size of ground coffee, which is by microns, a metric measurement. There are 25,400 microns to an inch or, to put it a different way, a hair is about 100 microns thick. The beauty of micron-sized measurement is that a single number reflects size a lot easier than, say, the expression that a grind is 0.004" thick. With this in mind, the following are representations of some typical grind sizes. (See chart #2)

So, particle size is critical for each brewing method illustrated, but why? The answer is two-fold: If we look at the particle size by grind, for a variety of grinds, we also can see the relationship between particle size and number of particles per gram. (See chart #3)

It is absolutely incredible to see how many particles are generated from just 1 gram, or about 8 whole beans of coffee! But that still doesn't tell us why grind is important. Now we'll see the final part of the equation. (See chart #4)

As can be seen by the graph, one coffee bean has a surface area of approximately 3.4 cm., or about the size of a postage stamp. Splitting that bean increases the surface area, correspondent with the reduction in particle size until, for a Turkish grind, we see that the exposed surface area is no longer the size of a stamp, but the size of a sheet of notebook paper! So the finer the particles of coffee and the greater the surface area, the more effective the hot water extraction will be in the preparation of the beverage.

The benefit of finer particles is that they have more surface area and less depth

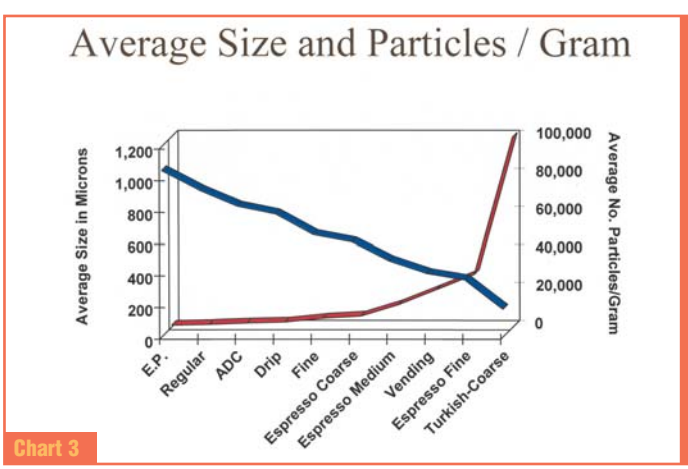

Chart 3

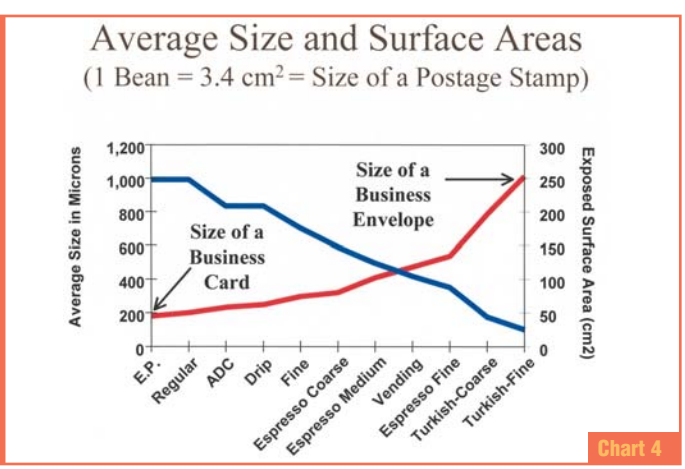

Chart 4

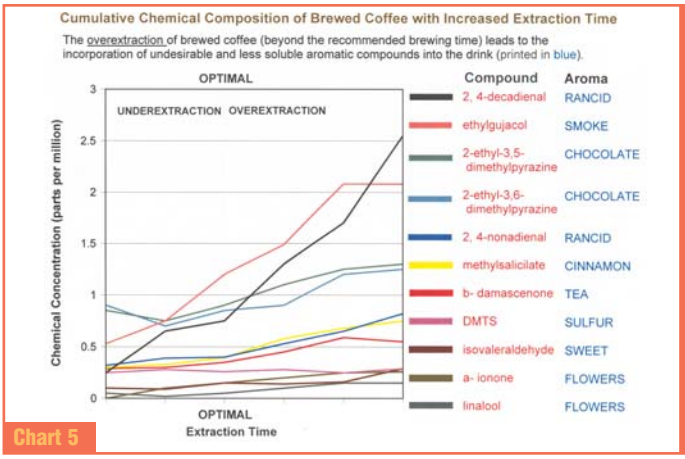

Chart 5

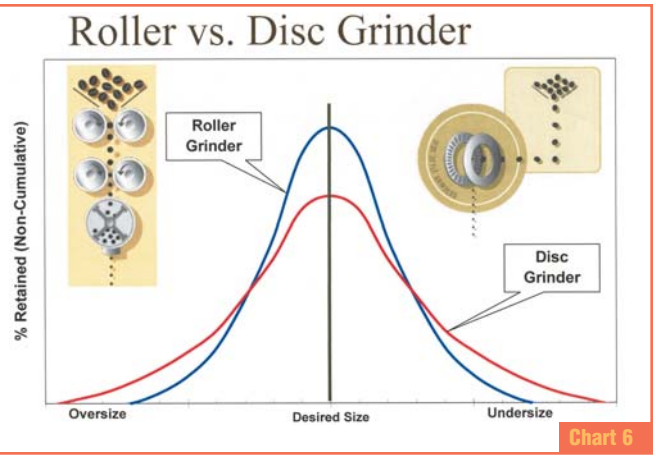

Chart 6

of cells through which the water must enter, which allows the soluble solids to diffuse out into the water more effectively. On the other hand, if the particles are too fine, the hot water will have difficulty passing through the layer of ground particles. This increases the separation time of the beverage from the grounds and causes over-extraction, a controlling (negative?) factor in beverage preparation. (See chart #5)

With each of those methods that we illustrate, it would be ideal for us to have all the particles exactly the same size since each method has an ideal size for extraction; the greater the particle size deviation, or variance, the greater the reduction in brewing quality. If we look at a filter-fine grind of, say, 645 micron, we would like all the particles to be exactly that particular size. But that's impossible so we strive for a tight distribution, or low variance in particle size. Remember, the more variance (less uniformity), the more any grind is ideal for a method other than that which we intended.

But something else happens as well. As we have more variance, we get more powder which causes the brew to over-extract, creating bitterness or reduction in coffee brew quality, which can be as much as 5-10%. Remember, we don't drink coffee beans, we drink the brew.

Again, to boil all of this down into a nutshell, the two critical factors in grinding coffee are:

Particle size = brew strength

Particle uniformity = brew quality

What drives uniformity? First, there are two primary types of coffee grinders, roller and disc. (See chart #6)

The beauty of the roller grinder is that, by design, it produces a "uniformity of grind"; however, these grinders tend to be more expensive and not as suitable for retail operations. On the other hand, the beauty of the disc-style grinder is that it's less expensive and more convenient for retail operations; unfortunately, the grind from a disc grinder inherently has more variance than the grind with the roller grinder.

Once we have our grinding equipment, the second part of the equation is grinder condition, or wear. Whether it's a roller or disc-style grinder, as rollers or discs begin to wear out, or require other maintenance, the grind variance deteriorates and voila, so does the brew quality. (See chart #7)

Defining and Measuring Grinds

Remember, we are interested in two things, particle size and uniformity. The traditional, historical method of analyzing a grind is the ro-tap process, which is essentially a series of screens which, when shaken, allow the ground coffee to filter from the top, or largest screen, through a series of screens to the bottom, or smallest screen, and into the pan. The result in each screen is then weighed, compared to the entire sample, and described as a % retained. (See chart #8)

The second method by which to measure particle size is laser methodology. In this case, as the laser beam hits the coffee particles that are crossing its path, a sensor measures the laser scattering and computes a particle size. (See chart #9)

Typically, a laser analysis will describe, in a computerized format, the grind distribution, both graphically and mathematically. The benefits of the laser method are its

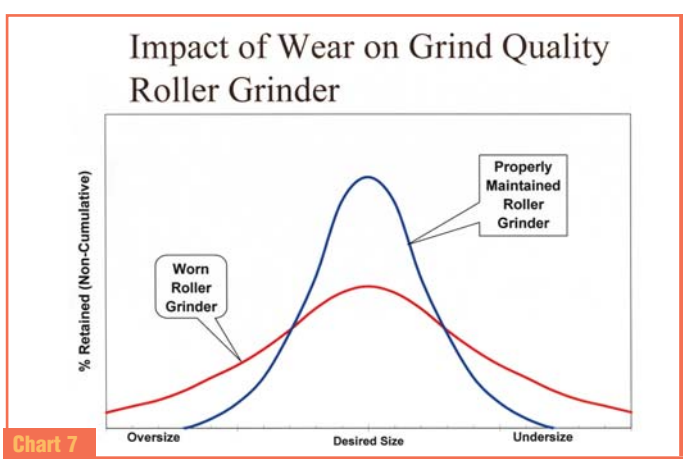

Chart 7

Chart 8

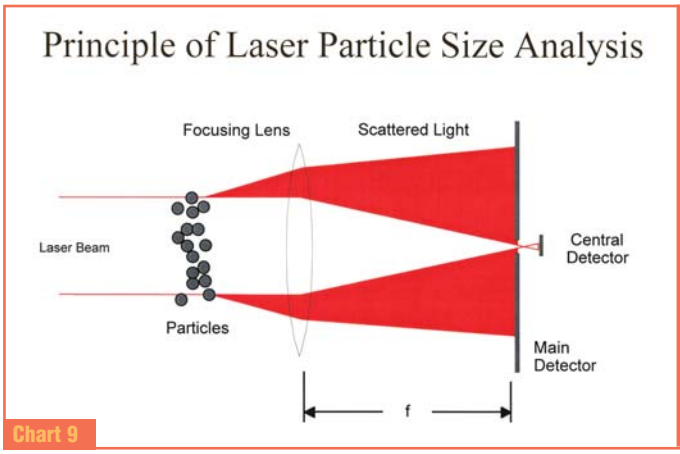

Chart 9

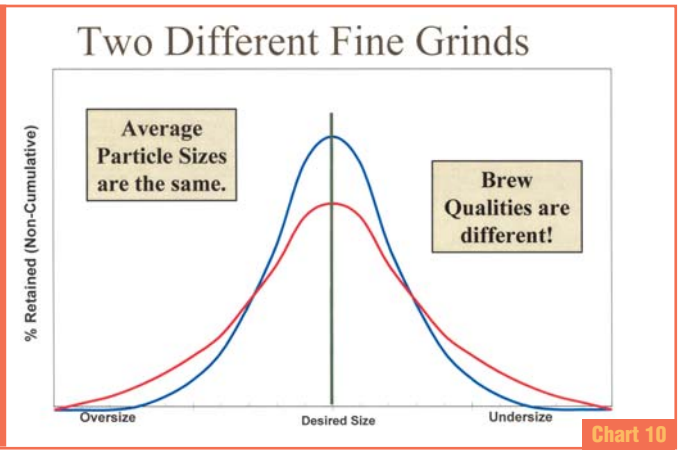

Chart 10

accuracy, speed, data acquisition and storage capabilities. The detriments are its high cost, its inability to relate to the ro-tap method and the tendency for the operator to look at and only measure average particle size, instead of the entire grind spectrum or variance.

This tendency to look at average particle size, rather than variance, has been a common practice with the laser analyzer and can cause difficulties since, unless it is used properly, it can disregard the primary criteria for beverage quality, which is grind variance. For instance, the following graph shows the same average particle size for two grinds and, while it is quite obvious which grind would have the higher quality beverage result, the average particle size is the same. (See chart #10)

In summary, there's a lot more going on in coffee grinding than meets the eye. Some of the more critical factors in grinding are:

Proper grinding is critical to brew integrity; Particle size controls brew strength; Particle uniformity controls brew quality; Particle size, the number of particles per gram of coffee and exposed surface area of those particles play key roles in brew quality; Particle analysis can be performed by both the ro-tap and laser methods; however, these methods are not interchangeable; The key downfall of laser analysis is the tendency to look only at average particle size (D50) and disregard the equally important variance information.

The above information, including reference materials, may be viewed in its entirety at: www.mpechicago.com/coffee.

With experience in the coffee business for over 25 years, Daniel Ephraim has been active in the development and design of coffee grinding equipment for the past 20 years. He has presented at numerous World Cup conferences and conducted over 100 coffee grinding seminars at coffee manufacturing facilities in North America and overseas. His company, Modern Process Equipment, Inc., is based in Chicago, Illinois.