Willem Boot started his coffee career at the age of 14 in his dad’s roasting retail store “The Golden Coffee Box” in the small town of Baarn, The Netherlands. While obtaining a master’s degree in business economics at the University of Amsterdam, Willem worked as a roast master, and learned valuable lessons about the promotion of single origin coffees. With his brother he acquired the family business and soon they started importing their own green beans, long before this became a major trend in the specialty coffee industry. The resulting direct relationships with coffee producers in countries like Panama, Colombia and Thailand inspired Willem to focus on the aspects of quality from the perspective of the farmer. Since the start of his consulting career, Willem has been working as a coffee taster, trainer and advisor for cooperatives, exporters and governments of coffee producing nations around the world. His activities generally include the implementation of quality improvement programs and the design of marketing and promotion strategies. Over the years, hundreds of professionals have travelled to his training studio near San Francisco, CA to attend roast profiling and cupping courses. In 2006, a long time dream became reality, Willem planted the first Geisha coffee tree in his forest coffee farm in Panama.

INTRODUCTION

The concept of designing quality at the level of the farm or the processing mill began initially in the 1950s with coffee producers in Kenya and later -in the 1980s- in countries like Brazil, Colombia, Panama and Costa Rica. With the proliferation of specialty coffees and the increasing number of roaster retailers seeking superior quality beans in North America, Europe and Asia, we have seen a rise in the number of producers who develop unique processing protocols for their coffee in order to create superior quality products and to gain a competitive edge in the specialty market. However, many producers on their own do not innovate with modifications of their production process.

The lack of innovation could be because coffee producers see no reason to become involved in the design of their own quality coffees. They may prefer to continue processing the coffee in the old way instead of taking risks and developing a new
process with an unknown outcome. They may fear that a process modification could alter the coffee flavor profile so drastically that they risk losing their traditional clientele overnight. These are just a couple of examples of common thoughts and doubts a producer might develop while contemplating the pros and cons of the implementation of new processing protocols while renovating the mill. This chapter explores options for coffee growers and their partners to improve the quality of their product through innovative approaches to post harvest management.

OPERATIONAL RESEARCH AND COFFEE PROCESSING

The world of coffee has been dominated for many years by paradigms which stem from the early part of the twentieth century. Traditionally, traders and importers have dictated the rules of the trade and the specific requirements of quality. With the proliferation of modern communication technologies, specialty roasters and producers have started to embrace concepts like “transparency” and “traceability”; current conventions in the global coffee industry are changing. Direct trade linkages between industry stakeholders have begun to dictate the rules for a new coffee production environment and as a result we are experiencing a coffee renaissance with a new awareness of the essence of coffee quality.

Traditionally, coffee production and processing techniques are set through unwritten rules and standards, which are commonly embedded in the prevailing coffee cultures of the region or the country. Generally, processing innovations start when the producer develops a distinct vision of how to market his product. Thus, he might change his strategy from competing against a large number of producers with similar products and, instead, develop a unique production process which enables his product to stand out among the large number of other coffees from the same country or region. Within this framework it is unlikely that a producer will attempt to design from scratch an entirely new system for processing coffee. Rather, as in the case of the prize-winning producer (see box), he is likely to observe small changes that he makes or that spontaneously occur in his operations and adopt those that are advantageous (see also Chapter 1.4).

Is there a preferred methodology for producers to optimize their processing styles? Although there is no fixed recipe for success, modification of day to day processing operations coupled with observation, recording and quantitative analysis of the effects of the planned or unplanned modifications can be very effective. In general, this approach or methodology incorporates five basic elements. First, processors should document each individual step of their production process on a regular basis to characterize the quality of each batch of coffee, paying particular attention to any unusual events or changes in coffee quality. For example, the ripeness of incoming freshly harvested cherries should be documented and associated with the flavor profile of that particular batch of cherries. Second, when planned modifications are implemented, they should be
incorporated with minimal changes to the rest of the process and the modification must be recorded. Third, coffee produced from unusual events or coffee created through planned modifications should be compared, using quantitative analysis, with coffee produced using standard procedures. Fourth, the newly developed products must be analyzed using sensory analysis, and these results, which have been duly recorded and stored, should be compared with the feedback obtained from clients. Fifth, once the beneficial effects of the novel processes have been tested and proven, results should be carefully monitored to ensure that the improvements are real. With these steps it should be possible to improve coffee processing without major investments and with minimal risk.

PROCESSING COFFEE FOR QUALITY

The post harvest process of coffee beans involves a critical cycle that starts with the carefully produced coffee cherry. Once the selection and harvesting of the cherries has been completed, a series of events starts that is aimed at creating a clean and unique flavor profile with an adequate level of sweetness, ideally complemented by desirable flavor attributes.

As in all processes, the outcome depends on the success of each individual step in the chain. If for any reason the outcome of an intermediate step is not successful, it will have a critical impact on the outcome of the entire process. For example, harvesting partially unripe cherries will jeopardize the crucial goal of sweetness in the cup. Without an adequate level of sugars in the cherries, even the most sophisticated process will not compensate.

The harvest and selection of cherries

Producing quality coffee is impossible without a proper strategy for selective harvesting of coffee cherries. Despite widespread awareness of the need for good quality ripe cherries to produce specialty coffee, producers around the world continue to struggle with this key task.

Debate is ongoing about the benefits of selective harvesting of only ripe cherries versus the advantages of strip-picking. Some specialty coffee gurus claim that all coffee destined for the specialty market should be harvested selectively and that only ripe cherries should be picked. On the other hand, many vendors of processing and harvesting machinery proclaim the economic benefits of strip-picking.

The coffee cherry comprises three layers around the bean. The outer layer consists of the mesocarp, which is also known as the pulp of the cherry. The color of this outer layer depends on the plant variety and ranges from burgundy red to deep red and yellow for ripe cherries. Below the mesocarp is the endocarp,
consisting of the parchment and the mucilage, which is a jelly-like slightly sticky layer rich in pectins. Finally, there is the ‘silver skin’, a thin paper-like fibrous tissue surrounding the bean. By weight, ripe cherries contain about 20% of green coffee beans (after drying, see also Table 1).

Six different stages of cherry ripening can be readily determined: In Figure 1 from left to right we see green, unripe, immature or partially ripe, ripe, overripe and raisin cherries (Figure 1, Six classes of cherry ripening).

What is the quality impact of these cherries and how should the coffee producer deal with variation in maturity of cherries?

The flavor impact of a green cherry (1st left, Figure 1) is generally quite unpleasant, lacking sweetness and with a distinct, astringent sensation. Green cherries should never be harvested and if they are picked by accident, they should be removed.

Unripe cherries (2nd from left) can potentially cause major problems later in the production chain: they are harder to depulp than ripe cherries. When the depulper is set to handle unripe cherries, the softer ripe cherries may be damaged and become more susceptible to fungal attacks. The unripe cherries have a sour, astringent and “greenish” flavor and should not be harvested. However, under certain circumstances this rule may have to be abandoned, such as when there are too few pickers for selective harvesting or when heavy rains disrupt the harvesting schedule and the pickers are instructed to harvest unripe berries.

The immature or partially ripe cherry (3rd from left) causes problems similar to those of the unripe cherry. There is a lack of sweetness and the flavor profile will contain a one-dimensional acidity. With immature beans, there is an increased chance that the silver skin will absorb pigments from the cherry during processing.
One can argue if “foxy beans” (a relatively common visual defect) are caused by immature cherries or by drying issues or by a combination of these factors. Most specialists agree that foxy beans occur when the silver skin clings to the green bean and displays a greenish or slightly reddish, tainted color. As some experts note, the reddish color might very well be caused by overripe cherries rather than by immature cherries.

Ripe cherries (3rd from right) have the highest possible mass that the fruit can develop due to an ideal balance between sugars, free water content, mucilage formation and overall coffee bean development. Ripe cherries are quite soft and can easily be processed with a depulper and with an optional mechanical mucilage remover. The sugar brix content can be easily measured with a refractometer. There is a need for ongoing scientific studies about the relationship between cherry Brix (measured in °Bx) and green bean quality. Ideally, the brix is between 20 to 24 °Bx, and there is some empirical evidence that for good quality coffee it should normally exceed 16 °Bx. However, several factors, including the weather and ambient conditions prior to the brix measurement can have a major impact on the measurement itself. For example, after a night of heavy rainfall (not uncommon in coffee producing countries) the degrees Brix can drop significantly and the sugars become more diluted inside the cherry due to the remarkable capacity of ripe cherries to absorb water. As a result, the measured Brix drops significantly due to the higher free water content inside the fruit. We can conclude that Brix levels must be interpreted carefully. The color of a ripe cherry depends on the coffee variety. There are different strains of bourbon: yellow, red and orange. Specialty varieties like Pacamara, Maragogype, and Geisha all develop their own distinct colors when ripe. Workers and pickers must be trained to recognize and select the right level of ripening for each specific variety.

Under almost all conditions, the specific weight of a ripe cherry is greater than that of an immature cherry. The ripe cherries are also heavier, weighing up to 20% more than immature cherries. These characteristics facilitate separation of ripe and unripe cherries.

Overripe cherries (2nd from right) are sometimes intentionally harvested by farmers in order to evoke winey, fruity flavors in the final cup.

Raisin cherries (far right) produce a dry aftertaste with tobacco-like flavors in the cup. The raisin cherries are easily damaged in the depulper resulting in cut and bruised beans.

**Selective picking or strip harvesting for ripe cherries**

Coffee experts around the world have a multitude of different opinions about the best strategies to produce quality beans. Most specialists agree that only ripe
cherries can result in top grade specialty coffee. However, there is a spectrum of opinions about the most practical way to produce ripe coffee cherries, ranging from selective picking to strip harvesting. Some specialists favor selective picking of ripe cherries in order to prevent quality problems downstream and, of utmost importance, to produce the best possible final result in the cup. Others suggest that with strip harvesting, ripe cherries can be selected by mechanical and/or siphon sorting methods which separate the heavier, ripe cherries from the lighter, unripe or immature cherries. If weather permits and if the farmer has sufficient access to labor, selective picking is preferred. However, labor may not be available for selective picking or may be exceedingly costly. Furthermore, variable weather can seriously derail selective harvesting, especially with heavy rainfall just prior to the peak of the season. Thus, although selective harvesting may be preferred from a quality standpoint, it is not always possible.

The practice of selective picking of coffee cherries is usually associated with the vision of the owners and managers of the farm. In general, it requires the availability of coffee pickers for a longer period than normal and the pickers must have a basic understanding of selective harvesting techniques. The main advantages attributed to selective harvesting are reflected first in the intrinsic quality of the beans and second in the reduction of problems in the downstream processing. The ripe cherries have a higher Brix and produce a sweeter flavor with optimum taste attributes. The uniformity of selectively harvested beans is a key feature that provides several advantages for processing and producing high quality coffee. Depulpers can be more easily calibrated with uniformly ripe beans, reducing the damage caused by cuts and bruises to the green beans. These cuts and bruises may cause problems later in the process. The composition and thickness of the mucilage is more uniform in selectively harvested beans, hence the fermentation process becomes significantly easier to control. To obtain good quality coffee beans in the traditional fermentation process, all beans should ferment at a similar rate and within the same time frame. According to some processing experts, with the mechanical mucilage removal process, the parchment beans can be cleaned more evenly with a possible reduction of the incidence of “foxy” beans. The uniform density of selectively picked cherries facilitates drying of parchment beans (improper drying practices are the root cause of many flavor taints in coffee). The beneficial effects of uniformity are also found in roasting: with a more uniform bean size and quality the roasting process can be optimized. Obviously the combination of all these features provides major benefits for the end user, the roasting company and the coffee house.

In a perfect world, all coffee farmers would harvest only ripe coffee cherries. Unfortunately, the reality of coffee farming is different. Farmers and their pickers often get caught up in a race against time. Erratic and intense rainfall may spur the development and ripening of cherries. If the fruit is not picked, cherries may bloat with excess water and fall. Rapid harvesting by stripping the cherries (also called 'milking' the tree) may be the only solution under these circumstances. If
climate change brings more variable weather, events that favor strip picking are likely to become part of the yearly farming routine. With strip harvesting, the number of picking rounds is greatly reduced. In some instances, all coffee cherries are harvested in less than three rounds. The final quality is usually disappointing. Ripe cherries must be sorted after the harvest by using special cherry separators. Some Brazilian coffee producers are now utilizing color sorters. However, even the most sophisticated sorters cannot distinguish between subtle differences in levels of ripeness, and after separation there will still be considerable variability with a mixture of immature, ripe and overripe cherries.

Apart from climate and weather conditions, there are other compelling reasons for strip-picking. Coffee is an important cash crop and many farmers wish to harvest their crop and receive cash as soon as possible (see Chapter 3.2). Obviously, the farmer only makes the extra effort and justifies the extra cost of selective picking if there is an incentive. Hence, unless there is a premium for producing higher quality coffee, strip picking is likely to become the norm. The rationale for strip-picking is often propagated by manufacturers of processing machines who promote their machinery with claims that their technologies can improve yield and quality at the same time. Under all circumstances, producers should be aware that the practice of strip-picking will generate a series of down-stream quality challenges that must be recognized and dealt with.

**CHERRY INSPECTION TO MEASURE QUALITY**

The quality of the coffee cherries is the starting point for determining the quality of the green beans. Should the producer just accept the incoming cherries as a fixed parameter that cannot be changed? Absolutely not! As a first step, the level of ripeness (described above) should be determined. This can be done by taking uniform samples of 300g from each incoming batch. All cherries in the sample are grouped according to the six classes and the percentage of weight per class is calculated (see Figure 2, Distribution of ripeness levels). Smaller producers may need to install inspection tables in order to sort the incoming cherries. This protocol creates an immediate profile of each batch of cherries, which in turn provides a valuable instrument of quality feedback to the coffee farmer and an important source of information for operational research. An added benefit, apart from improved control and monitoring of the process, is that some farmers are paid a premium if the ripeness level of the cherries exceeds a certain standard, whereas there may be a penalty if the ripeness is not up to par.

The sampling and inspection protocol of the cherries can be accomplished in 10 minutes or less, provided that the producer has a computer to store, calculate and display the information. A further advantage of inspection and use of a computer to store the data is that the processor can later use this information to relate the source of the cherries, their ripeness and the processing procedures
to the quality of the green beans and even the cupping quality of roasted beans. This information is vital for the necessary feedback of processing data in order to make further quality improvements. It should be noted that the above described selection methods are not commonplace in Latin America and beyond. In many cases, the pickers conduct their own selection procedures in the field prior to the bagging and weighing of cherries.

Figure 2 shows a classification with specific standards for three quality classes “A”, “B” and “C”. In this case, there were no “D” class cherries: this class could be penalized or refused outright at the gate of the processing mill. Overripe cherries can add a fruity and/or winey note to the coffee’s flavor profile which is not necessarily quality-prohibitive. However, producers and their partners should also be aware of the fact that overripe berries may lead to taints and defaults. The key benefit of this type of measurement and analysis is the ability to establish consistent processing protocols for each quality class. The classification of cherries allows the producer to predict the quality level of the final product. In addition, the analysis allows the producer to forecast the actual yield of exportable green beans, which is a key determinant of profitability for
coffee producers. In several countries, the use of cherry inspection and sorting tables has become an integral part of the specialty coffee production process.

A major question is whether smaller coffee farmers can separate coffee cherries. Inspection tables (80cm wide x 100 to 120cm high x 200cm long) can be manufactured using the same materials as East African-style drying tables (Figure 3, Inspection of cherries in Rwanda). Each table can seat two workers who sort out the green, unripe, immature and raisin cherries in separate buckets. The ripe cherries are dropped into a large bucket which is situated at the end of the table. Four workers at two cherry sorting tables can easily sort up to 600kg of cherries in an evening shift of two hours. This produces 100kg of exportable green coffee beans. As of early 2011, the labor cost of cherry separation in Central America was less than 15 cents per kilogram of coffee produced. The premium paid for higher quality green beans will almost always outweigh the initial cost of separation. Additionally, the producer does not have to make a heavy initial investment in machinery to sort cherries.

**PROCESSING OF CHERRIES**

Style and method of coffee processing are usually determined by tradition and general preferences of coffee buyers. Until recently, the sundried natural method was only used in a few countries, including Yemen, Ethiopia and Brazil. During the past years, coffee processors in several Latin American countries have been experimenting with natural sundried methods and hybrid methods like the honey process, in which most of the mucilage is left on the bean after washing. Many coffee buyers prefer the washed method for all or most of their purchased beans. They prefer the pure, clean and transparent flavor profiles of the washed method. Other buyers take a distinct interest in the flavor profiles of the sundried and honey processing style, often resulting in an array of tastes which had never before been associated with coffee. The debates about the pro’s and con’s of washing versus alternative processing styles are often fascinating. The resulting discussions frequently revolve around the true meaning of “terroir” and how the flavor of coffee can best be extracted from the cherries when it is processed. Purists generally point out that the washing process produces a cleaner flavor profile with taste attributes that are clearly displayed in the cup. Cuppers often identify this as the manifestation of a higher level of transparency, providing more opportunities for the genetics of the tree and the characteristics of the soil to filter into the cup.

**Dry versus Wet method**

From an historical perspective, the first commercial coffee harvests in countries like Yemen and Indonesia were dry processed. In the dry process, the coffee cherries are first dried, normally by natural sun drying, and then the dried product is hulled in a single step process to produce green beans. The dried cherry may
be stored before hulling. The freshly picked coffee cherry is highly perishable and under most conditions requires processing within 24 hours to prevent spoilage and rotting. Dry processing requires extended periods of sunshine and a dry climate. For this reason it is no surprise that coffee was first cultivated and processed in countries with very dry climates like Ethiopia and Yemen. The Dutch, who colonized Indonesia for more than 300 years, named the dry process “O.I.B.” (Oost Indische Bereiding), which can be translated as the East Indian Process. The dry process is well suited to areas with extended dry periods after the harvest. These favorable conditions prevail in the coffee growing areas of countries where large amounts of coffee were first produced: Brazil, parts of Congo, some parts of Indonesia, and Angola.

When coffee was introduced to the West Indies and the Caribbean region, the beverage enjoyed a growing popularity among consumers in the western world. The increasing demand for coffee spurred coffee producers to develop more efficient and faster processing methods, including the washed or wet process. With the newly developed protocols, producers could now process the coffee and dry the parchment beans in significantly less time. In the wet or washed process, the bean is mechanically separated from the rest of the cherry before drying. Wet processing of coffee uses more technical inputs than dry processing and requires the use of resources like water and electricity. Machinery for depulping, cleaning and drying forms an integral part of every ‘beneficio’ or washing station. The use of machinery makes the process faster and to a certain degree more controllable. There are limits to the extent of control, however, especially if the washing station is running at full capacity (which typically occurs at the peak of the harvest) and the quality of the green beans can be in serious peril.

Marketing and processing

The fascinating world of coffee consists of millions of small farmers who produce coffee on small plots of farmland. Some countries have an elaborate infrastructure of centralized processing mills for the production of washed coffee beans. However, in many coffee producing countries the cherries are processed at the farm (often with rudimentary processing equipment) or sometimes sold directly to an intermediary who processes them. The farmer often sells dried parchment beans to an intermediary buyer who finally sells the product to the exporter. These middlemen often make credit available to growers before the harvest and provide logistical services by aggregating products and by transporting the coffee to the nearest processing mill. These middlemen are often denigrated, but it should be noted that they do provide a service to the small farmers, even though some would suggest at an excessively high cost.

The involvement of intermediary traders in the supply chain often induces a series of post harvest processing defects. Producers will only attempt to supply high quality coffee if they receive a premium price or some other advantage such as a
long term contract with a guaranteed price coupled with credit for production of high quality coffee. Most middlemen lack the ability to evaluate coffee quality, they do not cup samples before purchasing, they are not aware of the price premiums for specialty coffees and they have limited knowledge of the effects of poor agronomic practices and inadequate processing on coffee quality. Hence, neither the middlemen nor the producers have the expertise to set a fair price for coffee as they are neither able to assess its intrinsic quality nor its value in the specialty market. A direct consequence is that many farmers do not consider the possibility of a premium price for quality and therefore make little attempt to improve it. Furthermore, these marketing arrangements often provide incentives to produce lower quality coffee. In the case of harvested cherries, farmers may attempt to collect unripe cherries as early as possible before the peak of the season in order to collect payment as quickly as possible. When selling parchment coffee at a fixed price and with no premium for quality, farmers will often try to under-dry their parchment beans in order to establish the highest possible weight count. These two factors - inappropriate selection of cherries and improper drying practices - form the root cause of more than two-thirds of all processing defects. Obviously, quality consciousness will not prosper if incentives for quality do not exist.

POST HARVESTING PROTOCOLS AND THE IMPACT ON QUALITY

In recent years, especially in Central America, a new generation of coffee producers has emerged. Instead of planting farms with conventional higher-yielding coffee types, these innovators plant heirloom or other coffee varieties which are revered for their cup qualities (e.g. Red and Yellow Bourbon, Typica, Caturra, Catuai, Pacamara and Geisha) and they produce their coffees with alternative processing styles (like the sundried natural and honey process) that are adapted to local conditions and that bring out the exotic flavors normally associated with Ethiopian and Yemeni coffee. Coffee producers enjoy at least four options for the processing of cherries, all of which have their advantages and disadvantages.

Natural Sundried Method (also called Dry Process or Unwashed Process)

In the natural sundried method, the cherries are rinsed and the floaters removed before drying either on a patio or on a raised drying bed. The first three days are critical for the final quality of the coffee. Intense sunlight is required to ‘skin dry’ the cherries in order to start the final drying process that should take less than fifteen days. During the first three days the moisture content of the cherries must reach 35% or less. Frequent rotation and movement facilitates uniform drying. The drying cherries must be protected against rain and condensation in
order to prevent flavor taints, with special attention to prevention of molds and fungi. The flavor profiles of natural sun dried coffee are intense, with potential attributes of dried fruit, leather, blueberry, fig and other notes.

**Traditional, Fully Washed Method**

The cherries are rinsed and floaters are removed prior to depulping. The depulped cherries are then fermented for up to 72 hours when the remaining mucilage is washed off. The washed beans are density-sorted in washing canals before drying either on patios, in mechanical driers, on static drying beds or by using a combination of these methods. The cleanliness of the system is critical: contamination from previous batches may lead to the formation of acetic acids and ultimately result in putrefied ‘stinker’ beans. This is one of the most potent processing defects: the smell and taste are truly undesirable. The flavor profiles of traditional washed beans can feature the aromatic notes of flowers (e.g. rose), an array of stone fruit (e.g. apricot, peach) and the taste is often bright, clean, transparent and with possible notes of green apple, citrus and other intricate traces of the ‘terroir’ of the coffee.

**Depulped Natural Process**

The depulped natural process begins in a manner similar to the traditional fully washed method. Upon depulping, however, the parchment beans (still covered with mucilage) are directly diverted to the patios or drying tables. The essential features of depulped natural processing and a comparison with the machine washed process are provided in detail in Table 2. Depulped natural beans are covered with the slimy, sticky mucilage (Figure 4, Depulped natural (above) versus machine washed (below), (Panama)). Some producers prefer to remove a small part of the mucilage using a so called ‘de-mucilager’ which washes and rubs off the mucilage. The drying process is key to the success of this method. The possible flavor notes include honey, sugar cane, molasses, chocolate and an array of additional taste subtleties.

**Machine Washed or Demucilaged Technique**

After depulping, the parchment beans are mechanically washed with the de-mucilager. Due to the continuous nature of this process, the producer must have sufficient capacity to immediately continue with the drying process of the parchment beans. Table 2 compares Machine Washing with the Depulped Natural Process.
### Table 2: Summarized Comparison of the depulped natural and the machine washed processes.

<table>
<thead>
<tr>
<th>Depulpled Natural</th>
<th>Machine Washed (Demucilaged)</th>
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</thead>
<tbody>
<tr>
<td><strong>Depulping</strong></td>
<td></td>
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<tr>
<td>The depulping process can be done with almost any standard depulping machine. It is up to the processor to decide how much water should be used. Some ‘honey’ producers prefer not to use any water at all, leaving all mucilage on the exterior surface of the parchment bean. Other ‘honey’ producers prefer to remove part of the mucilage (with a mechanical mucilage remover), which generally facilitates more controllable drying practices and more consistent cup profiles.</td>
<td>The depulping process is accomplished in line with a mechanical mucilage remover, which rubs the mucilage off the parchment bean. Most machines can be adjusted to maintain more or less mucilage on the parchment. With machine washed coffee, the producer generally aims for taste profiles that represent the ‘terroir’ of the coffee, rather than the flavor of the process.</td>
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<tr>
<td><strong>Drying</strong></td>
<td></td>
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<tr>
<td>The drying process can be tricky. Mucilage tends to be sticky, and the processor must prevent the beans from clumping together. Drying is accomplished best on raised beds on top of Hessian cloth (a fine-mesh, black cloth which holds heat and allows air circulation). Drying should be finished when moisture content is between 11 and 11.5%.</td>
<td>Demucilaged beans can be dried in various ways, as the beans are less sticky. Preferably, the coffee is first dried on a patio or on raised beds to remove excess moisture (up to 25% moisture content). The final part of the drying process can be accomplished with a cylindrical dryer to a moisture level of 12% or less at a modest temperature (below 50C).</td>
</tr>
<tr>
<td><strong>Resting</strong></td>
<td></td>
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<tr>
<td>Depulped natural beans and the ‘honey’ coffees can benefit from an extended resting time. This curing process is accomplished by storing the parchment beans in polypropylene bags with a black plastic liner. Resting allows the moisture to disperse evenly throughout a bean’s cell structure. Resting can take from 60 to 120 days.</td>
<td>In general, coffee benefits from a resting (reposo) time of at least 30 days. The resting time improves the shelf life of demucilaged coffee and some cuppers feel that longer curing times help to establish a more pronounced acidity. In past years, some processors carried out the resting process using wooden silos or drums, which presumably produce better moisture equilibrium.</td>
</tr>
<tr>
<td><strong>Benefits</strong></td>
<td></td>
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<tr>
<td>The key benefit of the depulped natural process is its suitability for the production of micro-lots. Little or no water and a minimum of machines are required. The efficiency and quality of the drying requires more manual labor and are extremely important in this process.</td>
<td>Machine washing requires more investment in machinery, which usually makes this process more relevant to larger producers with plots of at least 5 hectares or 20,000 trees. It should be noted that demucilaging requires only a fraction of the water used in the traditional washed coffee process.</td>
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FINAL RECOMMENDATIONS FOR OPTIMAL QUALITY SUCCESS

Processing Tips for Small Producers Using the Wet Process

The recommendations for small producers are aimed at producers with approximately 15,000 coffee trees or less. In order to create top quality coffee, it is essential to continually control the critical steps of processing and the resulting final product. It is only through this type of monitoring that the cup profile of the final product can be linked to variations in the process. This information can then be used to improve the control of the cherry-to-green bean process.

Producers should systematically organize their work to start the processing on schedule. Coffee cherries should be received before 4 p.m. in order to have sufficient time for cherry inspection, selection and processing. Inspection is essential under almost all conditions. Given the critical impact of the cherry quality, the producer must be able to validate the ripeness level of the incoming cherries. Without a proper inspection of the incoming cherries, the quality of the coffee can be a hit or miss affair. Virtually all successful specialty coffee producers inspect and select coffee cherries as an initial step in the processing cycle.

The traditional washed process uses at least three fermentation tanks of one cubic meter capacity each. Concrete tanks must be smooth and with round edges or finished with ceramic tiles. Polypropylene tanks are cheaper and can be more efficient. Utilizing three separate tanks allows the producer to separate lots and differentiate quality at the level of the processing mill. Wooden sticks are efficient tools to monitor fermentation in the traditional washed process. The stick is inserted into the coffee mass and then swiftly removed. If the coffee mass moves even slightly around the hole created by the stick, then the fermentation is not finished. Towards the completion of the fermentation, this test should be repeated at least every 15 minutes.

The quality of the water used for the fermentation and for the washing process must be monitored. Dirty, contaminated water can negatively affect coffee quality. Once the fermentation or the mechanical demucilage step is completed, the tank is filled with fresh water to rinse the processed coffee. The mass is mixed and stirred for at least five minutes to clean the entire coffee bed and floaters are removed with a strainer.

Before the drying cycle, the coffee beans should be separated according to specific weight or density in a classification channel. The coffee beans are allowed
to float downstream with the current and are then pushed back using a wooden rake. When the beans are released again, the lighter beans move faster along the classification channel and they can be separated from the heavier beans.

**Specific Tips for Establishing Optimal Drying Conditions**

The drying process can be a source of many downstream quality issues. Improper drying practices must be avoided to prevent unnecessary quality loss or the formation of molds during the storage and transport of the finished green bean product. The cells of the beans are saturated with up to 60% moisture, which is contained as free water inside the cell structure. During the drying cycle, the free moisture must evaporate from the bean at a consistent rate over time.

Basically, the drying process of parchment beans has two stages. The first stage (also called 'skin drying') may take from 6 to 12 hours during which time the internal moisture will be reduced from 55-60% to 20-25%. In the second ('final drying') stage, the moisture content is slowly reduced from 20-25% to 10-12% over a period of 8-24 hours. The success of the drying cycle depends on the distribution of moisture in the final product. If the drying temperatures are too high, the rate of moisture evacuation from the complex grid of coffee cells evolves in an uncontrolled manner and the distribution of free moisture inside the finished product is not uniform. Moist pockets with more than 13% moisture will develop inside the miniscule grid of the cell structure. Typically, these wet pockets make the green coffee bean unstable during shipping and storage. In the worst case, molds that accelerate quality degradation can develop.

Coffee can be dried either naturally in the open on a patio or raised bed or mechanically with either static silo driers or with large rotary cylindrical machines or with large vertical mechanical driers. For smaller producers, mechanical drying systems are not an option as they generally require major capital investments. For smaller producers, raised drying beds offer the benefit of a relatively low investment in materials. Furthermore, this method generally does not require any combustible energy source for the production of heat. The major benefit of raised beds is that they facilitate an even and gradual drying process, provided that the product is rotated frequently and that the mass of parchment beans is not packed too deep. The mass of parchment beans should preferably be spread out to a depth of 6cm or less.

Solar driers have been installed in a growing number of washing stations. A transparent structure is built around the drying beds that serves not only to trap the solar energy but also to protect the drying beans from rain. The structure must be well ventilated so that the moisture from the beans is removed from the structure.
Whether for natural drying in the open or in solar driers, ergonomic design of the drying tables is crucial. Drying beds that are too low or too high can make the job more difficult for the workers. A width of 80 to 100 cm facilitates rotation and movement of the coffee during drying as the workers can easily reach the middle of the drying tables. The tables can be made from locally available materials such as bamboo, wood or metal. Bamboo is easy to cut, has a high core strength and is relatively light. Eucalyptus wood is often used because of the abundant availability of this material in many coffee producing countries (see Figure 5, Coffee drying tables).

Drying beds with a metal frame cost more, but tend to be more rigid and last longer than wood or bamboo frames. Chicken wire is often used as the basic structure to cover the frame, with the beans spread on a finer net such as sturdy mosquito fabric or hessian cloth woven from polyethylene or nylon. A 3 to 4 mil agricultural plastic tarp is then used to cover the beans if it rains. With solar driers, a 3-4 mil transparent plastic sheet can be used to create a more permanent structure around the drying beds (see Figure 6). In the drier shown here, the frame is made from PVC tubing. The permanent frame should be positioned so that the prevailing winds evacuate the moisture from the drying beans.

The capacity of the drying beds depends on the design and measurements of the beds. With wet parchment, a drying table of 200cm x 80cm can dry up to 75kg of parchment beans spread to 6cm or less. With natural sundried coffee, a similarly sized drying table can dry 45kg of cherries with coffee spread to a depth of 4cm or less. The depth of the coffee mass must be limited to ensure uniform drying.

Condensation must be controlled when the drying tables are covered with a permanent or temporary plastic structure, especially at night when temperatures drop. Freshly processed coffee beans transpire rapidly and the water vapor must be allowed to escape from the area where the drying beds are installed. If the beds are installed in the open, the plastic tarp that covers the beans at night must be positioned so that there is sufficient free space above the beans for air movement and evacuation of the moist air.

**CONCLUSIONS ON MANAGING QUALITY**

All stages of processing should be recorded and documented. This information should preferably be displayed on large, visible boards in the mill. In this way, all employees will have a clear understanding of the processes and how they can improve them.

The workers should be trained to recognize critical stages of processing. The ability to use calibrated or standard samples for comparison is particularly important.
Once the coffee is processed, the relative humidity levels of the warehouse should be monitored to protect the parchment beans against deterioration due to poor environmental conditions in storage. The roof and the walls of the warehouse must be properly insulated to prevent any major temperature and relative humidity swings inside the warehouse.

Finally, and of critical importance, a cupping and quality laboratory should be installed in the processing mill so that the quality of the coffee can be measured and monitored and the flavor profile of the final product assessed.
S ome years ago, one of the winning coffee producers at a national coffee event in Central America exclaimed with a loud and happy voice how lucky he felt to have won a highly esteemed award in a national coffee event. During his speech to the collective crowd of international coffee tasters and national industry members he surprised the gathered audience with a compassionate story about his farm and the most recent crop of his coffee product release which had won the hearts and impressed the taste buds of the gathered coffee connoisseurs. During his talk he revealed how difficult the life and daily reality of a small farmer annex producer can be. For several years he struggled to keep up with the loan payments to the local bank and the gloom of foreclosure had become a frightening reality. His decision to participate in the highly esteemed coffee event became part of a last resort effort to take his future livelihood and the fate of his family in his own hands. He carefully selected a team of coffee pickers and instructed them to meticulously harvest only the ripe cherries. After a long day of harvesting, the pickers had collected more than seventy “quintals”, or at least 7000 pounds, of burgundy red, ripe cherries which, after processing, would produce at least ten full bags (each of 132 pounds) of green beans. Our friend felt elated. He had rarely been able to collect so many fully ripe cherries. At the end of the day, the “beneficio” felt festive with the purple red reflection produced by the rays of the evening sun blessing the cherries that were ready for processing. The foreman inspected the cleanliness of all the equipment and the tanks and gave the sign to start processing. There was a roar as the machinery started, then a total electricity blackout. To make matters worse, the backup generator was not working due to gasoline shortages. Our friend felt totally stuck and desperate; there was no way he could see to get his “beneficio” back in operation quickly. By the time power was restored, more than twenty hours had passed. He tried to slow the chemical process of fruit deterioration, which usually starts six hours after harvesting, by soaking the cherries in fermentation tanks filled with fresh, cold water. To make a long story short, he submitted this same coffee to the organizers of the competition and to his utter surprise, the coffee was not disqualified for being tainted. More amazing still, it made it into the finals and ultimately our friend won the quality competition.

So, what happened? Our friend’s coffee was caught in a perfect storm of lucky events which together revealed some unique, hidden qualities in the coffee cherries. The optimum ripeness of the cherries allowed the sugars to distribute evenly across the entire structure of the coffee fruit. Due to the
special circumstances, our producer friend initiated the processing of the cherries too late. Despite the delays, the cherries developed a remarkable spontaneous fermentation process which ultimately would induce a riveting flavor profile earning unanimous praise by coffee experts from around the world.

Perhaps the bacteria at the cherries were transformed into a perfect concoction of micro-organisms, which facilitated the formation of distinct floral aromatics and subtle fruity flavor notes. Possibly the parchment coffee beans received just the perfect amount of curing time for the coffee’s essential oils to distribute perfectly throughout the cellular structure. And one could ponder other questions: how influential was the roasting process and how critical was the final brewing procedure?

To understand coffee quality, we must strive to comprehend the possible chains of events (mostly of a chemical nature) that determine the final flavor in the cup. And here things get quite dicey; there are so many parameters that influence the process of turning the coffee cherry into a green bean that the experimental coffee scientist faces an arduous task. The challenge becomes even more grueling when we take into account the dynamic nature of consumers’ flavor preferences: taste trends continually change and processing experiments of today may define the consumer trends of tomorrow.

In the coffee industry, processing innovations become main stream if producers recognize the beneficial economic aspects of a new technology or of enhanced processes. Producers who cup their own coffee and who can adequately differentiate between the taste profiles of different samples possess a major competitive advantage over producers who do not cup their own beans.

With some lucky breaks like that of our prize winning coffee producer, we may be able to develop groundbreaking processing innovations to create exciting coffee flavors.

Overall, one can only conclude that there is no magic recipe or holy grail for the creation and processing of coffee beans. There are simply too many variables that must be taken into account at the same time.

By the way, our prize winning producer sold his winning lot to a ‘third wave’ coffee roaster from Australia at a record price. He was able to keep the local bank quiet, preserve his coffee legacy and save his farm.