# Coffee Wet Mill Processing Guide

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# Contents



# Background

Coffee is one of the world's most popular beverages, 60% of which is produced by 12.5 million [1] smallholder farms. The farmers who produce high-quality coffees find greater revenue opportunities through a market that rewards this quality. Similarly, businesses that follow good coffee processing methods to preserve quality can access higher value markets for their product.

This guide aims to provide wet mill managers in East Africa with guidelines on preserving Arabica [2] coffee bean quality during wet mill processing. This guide starts with an introduction to the coffee fruit and common processing methods used in the region, followed by step-by-step guidance on the wet mill processing process (cherry receipt, pulping, mucilage removal, washing, drying, and storage).

The guide ends with a section on wet mill economics and a section on sustainability concerns. Throughout the document, links to useful tools can be found, and at the end of the guide, a link to the coffee process summary checklist can be used to perform daily quality processing checks at your own wet mill.

[1] Enveritas data, 2019
[2] While both Robusta and Arabica coffee varietals are grown in East Africa (Uganda being the largest Robusta producer and Ethiopia the largest Arabica producer in this region), this guide will focus on the washed processing method for Arabica coffee, as the quality premiums are generally higher and this method is most common in the region.

# The Coffee Fruit

The coffee fruit is often called a 'coffee cherry' and is comprised of several layers: the green coffee bean, silver skin, parchment, pulp/mucilage[3], and skin.

The layers surrounding the bean provide protection, and as the coffee fruit matures, the mucilage softens which helps to release the seed during pulping. The bean is the most valuable part of the coffee fruit because it is the product sold to coffee buyers. A freshly harvested coffee cherry has as moisture content of approximately 65% and the coffee bean has a 10-12% moisture content when exported as green coffee.

During the initial stages of washed processing, the skin, pulp, and mucilage are removed to leave the coffee bean surrounded by a silver skin and parchment layer. This is called parchment coffee and is carefully dried, stored, and transported to the dry mill for milling.

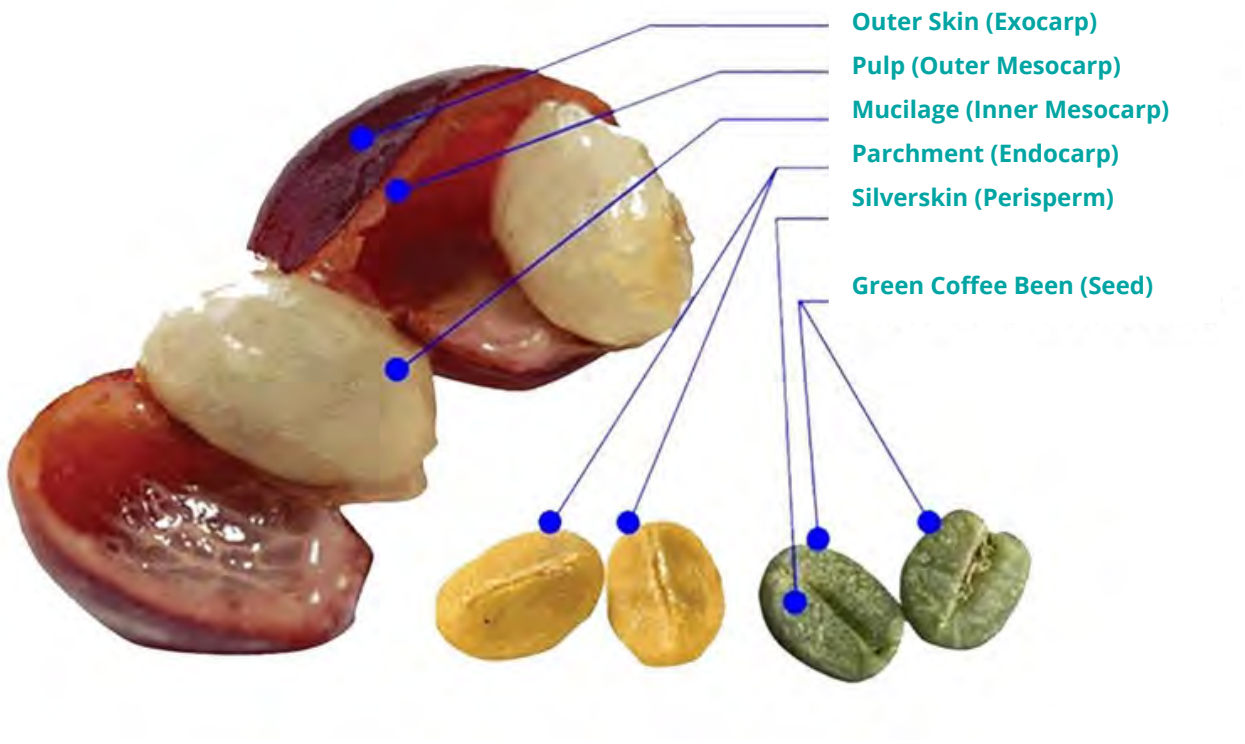



**Figure 1: Anatomy of a coffee cherry [4]**

The whole process requires a great deal of care to preserve the quality of the bean. For instance, when mucilage is retained on the parchment surface, there is an increased risk of mold, defects caused by over fermentation, or rotting during drying and storage that affects the final quality. Achieving high-quality coffee is not about doing one step with excellence, but rather ensuring that proper protocols and best practices are followed across the entire process from tree to cup.

[3] The part of the pulp remaining on the bean after pulping is called mucilage.
[4] Source: https://www.coffeelabs.com

# Common Coffee Processing Methods

When compared to other agricultural products, coffee is harvested at a comparatively high level of moisture, presenting the processor with challenges for preserving quality. Traditionally, coffee processing has focused on bringing the coffee bean moisture levels down to a stable point while minimizing the costs to do so. Recent market trends have caused coffee processors to prioritize and focus on the flavors that develop through various processing steps, leading to an array of processing method names.

The three main methods to process coffee are:

### Washed

coffee fruit is pulped; mucilage is "loosened" through fermentation; washed clean of mucilage; and then dried [5]

### Honey [6]

coffee fruit is pulped and dried with mucilage intact [7]

### Natural

coffee fruit is harvested and dried as a whole fruit

These methods are best understood by considering the different actions involved in the process:

### Pulping

Pulping - the process of removing the skin and pulp, leaving behind mucilage attached to the parchment layer with coffee seed inside.

### Mucilage Removal

Mucilage Removal - this step involves removing the remaining mucilage through biological (fermentation[8]) or mechanical means (there are many variations during this step where partial mucilage removal occurs via machinery and fermentation is utilized to loosen the remaining).

[5] The term semi-washed is often used when the process involves the mechanical removal of total or partial mucilage, regardless of if a fermentation step is used. However, across the industry there is no consensus how this should be classified. Furthermore, semi-washed can also be used in E-Africa as distinguishing coffee that has been home processed versus that processed at a washing station (fully washed).Many variations (mainly related the amount of mucilage left) exist that change depending on regionality and customs.
[6] At times, the terms 'pulped natural 'is used instead of honey which could either refer to the exact same processing method or include partial mechanical removal (uncommon in East Africa).
[7] Many variations (mainly related to the amount of mucilage left) exist that change depending on regionality and customs.
[8] Once the coffee fruit is harvested, there is potential for fermentation to occur at any step. Fermentation is the biological process where microbes are consuming compounds producing energy for themselves and metabolites as by-products. This process "loosens" the mucilage from the parchment and allows for ease in washing. Most often the stage that occurs after pulping and before washing is called: "fermentation." For simplicity, we will use this understanding as well.

## Washing

Washing - separating the mucilage layer from the parchment coffee through the use of washing channels, buckets, or machines.

## Drying

Drying - applying heat (solar or mechanical) to reduce the moisture from within the coffee bean (seed) to a stable point of 10-12% moisture w.b [9].

Therefore, we can define the above main methods using an understanding of their action steps:

| Processing Method | Pulped | Mucilage Removal | | Washing | Drying |
|---|---|---|---|---|---|
| | | Mechanical | Fermentation | | |
| | Skins and pulp are removed | Mucilage removed by machine | Mucilage removed by enzymatic reactions | Mucilage is separated from parchment | Parchment/cherry is dried |
| Washed | | Variations exist across regions | | | |
| Natural | | | | | |
| Honey | | | | | |

**Figure 2: Coffee Processing Method Matrix**

Washed processing is the most common of the three processing methods used in East Africa for processing Arabica coffee. Given the global and regional importance of the washed process, this guide will solely focus on this processing method.

**Figure 3: Example of washed parchment, honey parchment and naturals on the drying tables**

[9] w.b. = wet basis. This is defined as the amount of moisture in the seed as a percent of the total weight.

# Wet Mill Processing Steps

## 1. Cherry Receipt


**Figure 4: Wet mill processing steps**

**Selection of raw material**

The first step on the path to high-quality coffee is ensuring the coffee fruit (raw material) is of highest quality. While this includes many aspects of agronomy outside the scope of this manual, a first critical step for wet mills is to advise farmers on the best way to harvest, handle, and transport coffee cherries to the central mill. In East Africa, manual harvesting is the prevalent method utilized. As such, the best way to achieve high-quality coffee is by a selective harvesting method targeting cherries at a bright to deep red, ripe stage.

As the cherry ripens, it increases the amount of compounds directed toward the seed, and the mucilage softens. This makes it easier to pulp, increases cherry weight (so the farmer gets paid more) and improves the quality potential of the coffee (higher revenue potential). Cherry ripeness (through selective harvesting) is the first critical step on the path to high-quality coffee and presents a win-win for both the farmer and the wet mill.

Establishing a target ripeness range can help wet mills maintain consistency in processing as well as provide a measurable way to communicate expectations and set price levels with harvesters. Figure 4 below provides a visual representation of a quality target range. More than 90% of the coffee cherries should fall within this range to increase chances to produce a high-quality coffee. Starting processing with fully ripe cherries is essential for achieving consistency between batches and a high-quality processing output. Accepting and paying for unripe cherries represents a business loss to the wet mill which buy cherry at local market prices, incur handling and processing costs, and then must sell this product, often at a much lower price.

## How to measure cherry ripeness with the use of a refractometer (if you have one)

A way to measure cherry ripeness is to use a refractometer (~$10) measuring the concentration of solids present in the fruit juice which approximates the sugar content of the mucilage. The riper the cherry, the higher the sugar content which is expressed in a brix score (%). Brix values are not a direct indicator of quality. We use the Brix values to support our decision for establishing a target ripeness range. Brix is measured using a refractometer. Use the following steps to use this tool:

1. Calibrate the instrument using distilled water (water should read 0)
2. Place a small amount of mucilage on the surface of the prism (by squeezing the cherry)
3. Close the glass and point the prism end toward a light source
4. Look through the eye hole and determine the line where blue and white meet
5. Clean the prism surface with distilled water
6. Repeat

Note that brix values are contextual to an area (eg. ripe cherry brix values can range from 15-25) and therefore should preferably measured by the wet mill itself to determine the ideal cherry ripeness color in their area. To determine your cherry ripeness range using a refractometer take the following steps:

1. Select coffee fruits from green to black from trees.
2. Layout coffee fruit from unripe to ripe (as in picture below)
3. Measure brix levels from 3-5 fruits of each ripeness level
4. Write down average scores per ripeness level 5. Identify what external color represents a peak in Brix.

**Figure 5: The refractometer (left) and the brix value reading (right) as looking through the refractometer lens (13% in this case)**

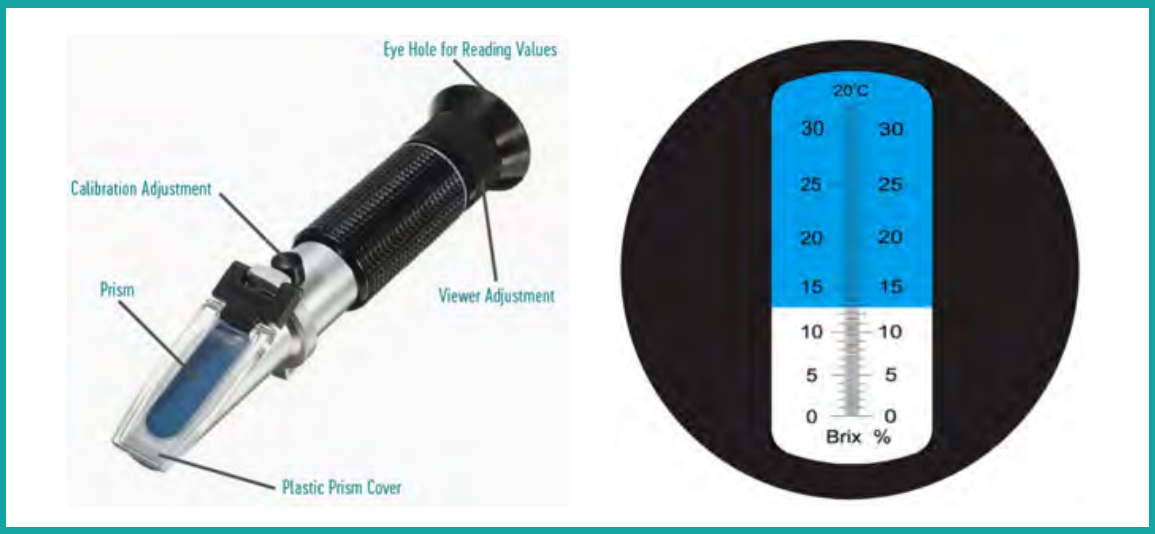


**Figure 6: Cherry picking quality target ripeness stage [10]**


## Cherry Harvesting Guide

- Start to harvest in the morning to ensure early delivery to the wet mill.
- Harvest coffee by selective harvesting of bright to deep red, ripe cherries. Do not harvest unripe or immature cherries. Do not delay harvesting until cherries are overripe or dry. While not always the case, experience shows that farmers tend to harvest cherries too early and are not selective enough. **NOTE: Red ripe cherry is easier to process and has higher quality potential, so the coffee can fetch better prices in the market.**
- Ripe cherries also have more water and are more than **30%** heavier than green or overripe cherries[11]. A good argument to convince farmers to selectively harvest is: "If you harvest more often, such as every couple of days, and you only pick red ripe cherry you are selling water, have more kilograms of cherry and make more money!"
- Farmers should use a container that can be put around their neck or waist and a clean bucket that can be carried around during harvesting.
- Use clean containers to harvest and keep harvested coffee out of the sun (under shade) as much as possible.
- Cherry fallen to the ground before harvesting should not be mixed with harvested cherry since it is generally old and of inferior quality.
- If the farm area is too large to harvest in a single day, a harvesting regime can be set up under which each day another part of the farm is harvested (focus area), after the last focus area the workers return to the first focus area making sure to return to each area every few days as per schedule.
- Directly after harvesting, spread a clean plastic sheet/tarpaulin under shade and sort the cherries; remove any unripe, overripe, dried cherry, and any foreign objects (leaves, twigs, stones) present in the harvest.
- It is important to sort cherry before delivery to the purchase point as this saves farmers time and reduces the quantity they have to carry, as well as no rejected cherry to carry back home.

[10] Top left photo source: https://perfectdailygrind.com/2016/02/coffee-science-how-can-we-identify-improve-cherry-ripeness/ with original credit to Cafe Pacas. Bottom left photo credit: Coffee Quality Institute.
[11] The growth of the coffee berry, T.M. Wormer, Coffee Research Station, Ruiri, Kenya, 1961.

- Deliver the coffee to the wet mill immediately after harvesting and sorting. It is advised to pulp coffee within 6-8 hours of harvesting to preserve quality. Therefore, it is advisable to encourage farmers to deliver early in the day to start pulping as early as possible.

  Tip: If it so happens that more than 6-8 hours have lapsed since harvest and cherries are not yet pulped, it is advisable to rinse the cherry with cold water to keep it cool and prevent fermentation from advancing.

- Package and transport coffee fruit in clean bags, keep in shade, and do not put any heavy objects on top of the coffee. Transport cherry in clean bags that allow for proper ventilation (if the bag is not ventilated, then poke small holes with a needle to improve ventilation). Ensure no cherries are left inside the harvest bags.
- The overripe, unripe, dried cherries, and other discarded fruit can be dried and sold separately as natural processed to the local market. Where paid labor is used, pay harvesters more for fully ripe cherry, less for overripe cherry, and even less for unripe cherry to create the right incentive system. Any unripe cherry picked presents a business loss to the farmer.

Once the coffee cherries are harvested, they are delivered to the wet mill for pulping which involves cherry collection, sorting, weighing, and issuing of a receipt.

**Figure 7: Selective harvesting of cherries**

**Figure 8: Cherry receipt steps**


## Cherry Collection Process

After harvesting, coffee cherries are either transported directly to the wet mill by the farmers or delivered to the collection centers that are then delivered in bulk to the wet mill. Wet mills should attempt to buy cherry as close to the farm as possible to support farmers to deliver regularly. Likewise, wet mills are advised to encourage collection site agents to start deliveries to the wet mill early (e.g., whenever a small truck can be filled up) instead of waiting until the end of the day. The wet mill should open in the morning for deliveries (e.g., from 10am onwards) and close early (e.g., 4:30 or 5pm) to allow enough time for re-sorting at the wet mill and avoid late pulping. The earlier the wet mill can start pulping, the earlier the work will finish and the less time there is between harvesting and pulping. However, each situation is different and requires attention to timing and schedules that will vary across region and situation.

To coordinate coffee cherry arrival at the wet mill, ensure there is proper cherry receipt volume planning and communicate cherry reception hours. Clear delivery hours and protocols need to be communicated with all delivering farmers. It is possible to stop buying when a certain daily volume target is met as well as when the reception hours are passed. To help achieve quality consistency, it is important to have all coffee processed in consistent, stable conditions (e.g. cherry temperature[12]). The variations that exist across different farms, daily environmental conditions, and even the packaging used to transport coffee bring with it their own unique conditions that present challenges to maintaining consistent quality.

**Figure 9: Cherry sorting**

[12] When cherries arrive at different temperatures, this can be regulated by submerging or dipping into water to cool down the cherries (allowing removal of floaters at the same time). This has the added benefit of reducing microbial activity and standardizing temperature before pulping and subsequent mucilage removal.

## Cherry Sorting Guide:

- Develop a precise schedule of delivery times at each collection center and ensure farmers understand the schedule to minimize delays and vehicle hiring costs. Collection centers must operate at fixed times only. If farmers live within a 3-5 kilometer radius of the wet mill, direct deliveries should be encouraged as stricter quality control can be exercised (for instance by offering a higher price at the wet mill compared to the collection site in lieu of having to pay commission to site collectors).
- Sort cherry at collection centers (and perform a quality check on this at the wet mill). Cherry ripeness is found to be an important factor in deciding quality of the resulting coffee and influences the cupping score. The closer to the farm that cherry selection is done, the lower the cost to the wet mill.
- Perform spot checks on bags delivered by collection agent to ensure the sorting at collection site was well done, by emptying randomly selected bags of cherries and perform a quality audit as described below. Pay collection agents only for ripe coffee cherry delivered and not for unripe to create the right incentive system. If too many underripes are present, the delivery should be rejected outright. If the bags are still accepted, a lower price should be paid to penalize the agent for inaccurate sorting at collection center as re-sorting still needs to be performed at the wet mill.
- Perform a quality audit on coffee cherries by:
    - Spreading out and visually observing cherry for foreign matter and prevalence of unripe or overripe cherries. Take random samples and measure the percentage of cherries that are inside the targeted ripeness range (e.g., 90%) and pay the site collector accordingly.
- For direct deliveries, reserve a separate sorting area at the wet mill where coffee cherries are sorted before proceeding to the weighing area. At the sorting area, ensure farmers remove unripe, immature, overripe, and dried cherries, and any foreign materials (stones, twigs, and leaves) present so that only fully ripe cherries are weighed and pulped.
- Spread clean, polythene sheets or tarpaulin to sort raw material, or use raised, sorting tables.
- The coffee cherries not meeting ripeness criteria are either returned to the farmers or they are bought at a lower price. These can be processed by the natural method (whole fruit dried), sold separately to the local market, and recorded as income for the wet mill.

## How to calculate your maximum coffee cherry intake capacity

Each coffee pulping machine has a recommended/suggested per hour capacity. To calculate the pulper capacity, multiply the hours of operation by the per hour capacity of the machine. Example: A single disc can process approximately 1,000 kg of cherries per hour and an Agaard pre-grader, often linked to a three-disc pulper, can grade 3,000 kg of cherries per hour. Assuming the pulper effectively operates six hours a day, the pulping capacity of a three-disc pulper would be:

**Daily capacity:** pulper hourly capacity (Mt) x average no. hours = capacity per day (Mt)

| | | | | |
|---|---|---|---|---|
| **Example:** | 3 | x | 6 | = 18Mt/day |

[13] Oftentimes, pulper capacity is least likely to be a limiting factor. The wet mill can decide to operate additional hours or purchase more equipment.

## Capacity of fermentation tanks

A three-disc pulper approximately requires 16 fermentation tanks (3m x 2.5m x 1.1m), 20 skin drying tables (15m x 1.8m), and 80 final drying tables (23m x 1.8m) to complete processing. After the coffee fruit is pulped, parchment coffee with mucilage intact is placed into a tank or vessel for fermentation. When calculating the capacity, remember to use an average of how long the parchment coffee must remain in the tanks. To calculate fermentation tank capacity begin by measuring the tanks orvessels to determine the total volume (e.g., length X width X height = total volume). Then multiply by the number of tanks. Assume that 1,500 kgs [14] of cherries produces 1 m3 of wet parchment (parchment coffee with mucilage intact). This will provide the total possible capacity of a mill's fermentation tanks; however, remember to take into account the duration of fermentation. If fermentation times are 36 hours, round up to 2 days and divide the total capacity by this number. (*Note: Do not forget that each grade produced from pulpers will need separate fermentation tanks. If using a system that produces multiple grades, factor separate tank requirements into estimations).

Example for 10 fermentation tanks for grade A coffee of 3m x 2.5m x 1m with fermentation lasting 36 hours.

**Daily capacity**: length x width x depth x Mt per m3 x # tanks / # days fermenting (round up)

**Example:** 3 x 2.5 x 1 x 1.5 x 10 / 2 = 56Mt cherry/day

## Capacity of drying space

Often, the available drying space is the biggest bottleneck at a wet mill. This stage not only depends on having dedicated space over an extended period of time, but it also depends greatly on the weather. Being able to effectively and efficiently manage drying areas is a significant component of producing high-quality, consistent coffees. To calculate the drying space needed, we begin by assuming that 1m2 of drying space will hold roughly 10-12 kg of dry parchment (12-15 kg of wet parchment). Further, each wet mill needs to understand, on average, the number of days required to dry coffee (using the standards described below in the drying section). Once the average drying time is confirmed, calculate the drying capacity using the total drying surface (length X width) of all drying tables and multiply by 10-12 kg of dry parchment. Then, divide this number by the average days of drying. Convert the result from dry parchment to fresh coffee cherry to understand the wet mill capacity. Do this by multiplying the dry parchment figure by 5.

**Daily capacity:** dry parchment kg per m2 x length x width x # final drying tables / # days drying x 5 / 1,000

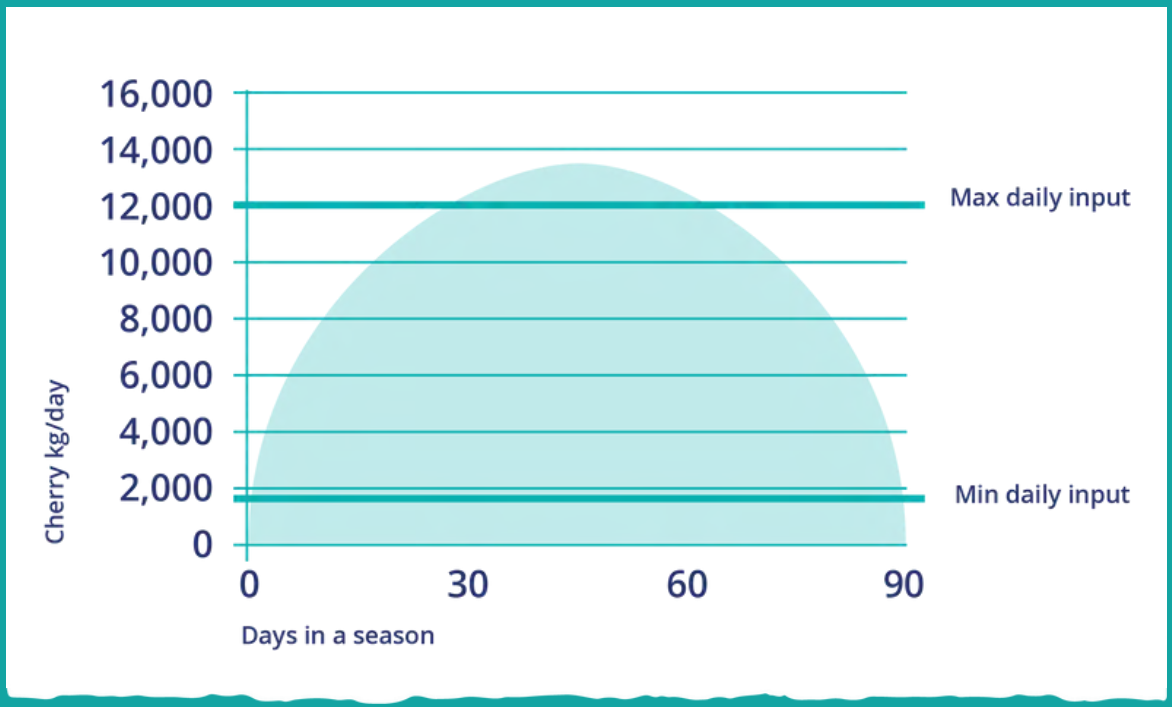
**Example:** 11 x 25 x 1.8 x 80 / 14 x 5 / 1000= 14 Mt cherry/day intake volume

[14] This would be 800kg of wet parchment. Montilla-Pérez et al (2008). Propiedades físicas y factores de conversión del café en el proceso de beneficio. Avances Técnicos: Cenicafe 370, 1-8.

In case drying tables are not in top condition multiply the final number by a % of available surface space (e.g., if 80% available, multiply 14 Mt/day by 0.8 and get 11 Mt/day as the effective maximum daily cherry intake volume).

The sample graph below shows the anticipated cherry intake of a wet mill with a maximum 12 Mt/day capacity over the course of the season, including a cut-off point to reject cherry intake above the maximum capacity delivery during peak season. Knowing when to accept and reject cherry is essential to the smooth operation of the wet mill. To ensure consistency between daily batches it is better to stop buying after the targeted quantity of cherry has been purchased on a day rather than overbuying on that day and pausing next day purchases. Daily buying of similar volumes ensures consistent processing conditions.

**Figure 9. Wet mill throughput**
Cherry kg/day

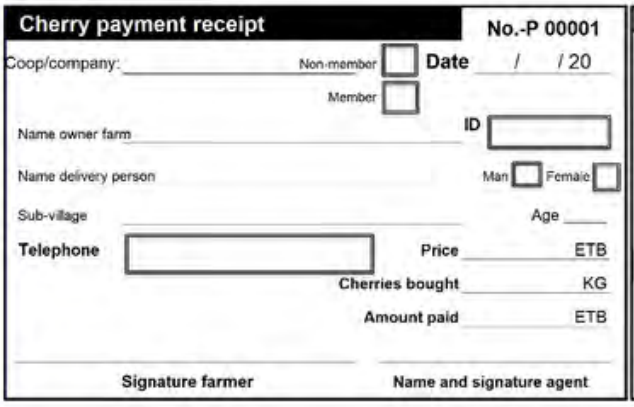


## Coffee Cherry Weighing:

- The farmer receives payment according to the weight and quality of the raw material delivered.
- The weighing scale must be properly calibrated and accurate. In most countries, this is done by the weights and measures authority on an annual basis.
- Wet mills are encouraged to adopt digital weighing scales. These are easy to use, and the scales often have provisions to print receipts to manage farmers' delivery data.
- After weighing accepted raw material, the coffee cherry should be temporarily placed under water in a floatation tank, if present, to remove floaters (e.g., insect, defective, dried, and low-density coffee fruit) and to regulate coffee cherry temperature, before carefully being put into the hopper for pulping. Do not keep cherry submerged under water for too long as it can lead to leeching of sugars which are useful during fermentation so once floaters are removed the water can be drained and cherries placed in the pulp hopper.
- The pulping should start whenever there are enough cherries present to prevent uncontrolled fermentation of the coffee fruit.
- Clean the hopper well before and after pulping; remove any trapped coffee cherries from the previous day.

## Issuing Receipts

- The farmer is paid for the amount of coffee cherry delivered and given a sales receipt for their records. An example of a receipt below.
- In case the wet mill buys cherries on credit from the farmers (e.g., when they run out of working capital to pay cash on delivery) a cherry credit receipt should be used to be able to separately trace volume and cash flows.



**Cherry payment receipt** No.-P 00001

Coop/company: Non-member ☐ Date / / 20

Member ☐

Name owner farm ID ☐

Name delivery person Man ☐ Female ☐

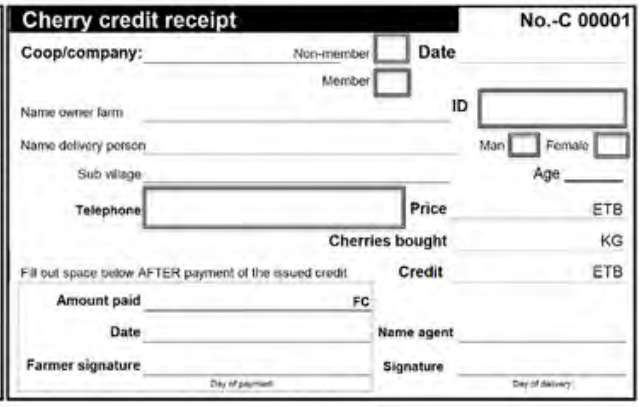
Sub-village Age

Telephone ☐ Price ETB

Cherries bought KG

Amount paid ETB

Signature farmer Name and signature agent



**Cherry credit receipt** No.-C 00001

Coop/company: Non-member ☐ Date

Member ☐

Name owner farm ID ☐

Name delivery person Man ☐ Female ☐

Sub village Age

Telephone ☐ Price ETB

Cherries bought KG

Fill out space below AFTER payment of the issued credit Credit ETB

Amount paid FC

Date Name agent

Farmer signature Signature

A register of cherry deliveries should be kept so that any volume differences can be traced and a delivery list of all farmers can be compiled for either traceability or second payment (profit share) purposes. An example of a daily cherry delivery register below.

**Cherry register (delivery and payment) per collection site** — **N° - CR 00001**

Date: / /20

Name collection site: Coop/company: Amount - start of day

| | N° Receipt PXX/ CXX/ DXX | ID farmer | Name farmer (at least three) | Name delivery person | SEX / AGE | CASH payment: Price (ETB/Kg) | CASH payment: Cherry delivered (Kg) | CASH payment: Amount paid (ETB) | CREDIT delivery: Cherry delivered (Kg) | CREDIT delivery: Credit amount | Payment of old credit receipt: Date de delivery | Payment of old credit receipt: Old price (ETB/K | Payment of old credit receipt: Cherries to be paid | Payment of old credit receipt: Amount paid (ETB) | Signature farmer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | | | | | |
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| 20 | | | | | | | | | | | | | | | |
| | | | | | | | 1 | A | 2 | | | | | B | |

Total Cherry delivered 1+2= Kg

Total amount paid A+B= ETB

Amount - end of the day

Signature agent

- The collection agent is paid for the amount of coffee cherry delivered and accepted (depending on results of the quality audit) and given a delivery receipt for their records. A cherry delivery register should be kept at wet mill (example below). In case the wet mill does not work through collection sites, with all farmers instead delivering directly, this step is not needed.

## Cherry delivery report at wet mill

No - CD 00001

Week of

Wet mill station:

| Day / Collection site | Monday | | | Tuesday | | | Wednesday | | | Thursday | | | Friday | | | Saturday | | | Sunday | | | Total accepted |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Kg delivered | Kg Accepted | N° receipt T. | Kg delivered | Kg Accepted | N° receipt T. | Kg delivered | Kg Accepted | N° receipt T. | Kg delivered | Kg Accepted | N° receipt T. | Kg delivered | Kg Accepted | N° receipt T. | Kg delivered | Kg Accepted | N° receipt T. | Kg delivered | Kg Accepted | N° receipt T. | |
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| 24 | | | | | | | | | | | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | | | | | | | | | | | |
| Total accepted | | | | | | | | | | | | | | | | | | | | | | |

# 2. Pulping

Cherry receipt

Pulping

Mucilage removal

Washing

Drying

Storage

The pulping step involves the mechanical removal of the skin (exocarp) and pulp (outer mucilage) leaving behind the parchment with silverskin and seed inside and (inner) mucilage adhered to the outside of the parchment. This step not only initiates a biochemical response inside the seed but also exposes the coffee to risks of defect development if not monitored correctly. The first step in pulping is pre-cleaning.

**Pre-Cleaning**

Each batch of coffee fruit comes from a different farm, can vary in total weight, and carries with it its own unique conditions (temperature, harvest time, microbiota, etc). Pre-cleaning encourages uniformity among the different batches being combined in a single day's production. Coffee cherries can be cleaned or sorted based on color, size or density. Color based sorting is done by people sorting by hand as been discussed under cherry sorting (p10) [15]. This is the only pre-cleaning technique focused on separating based on ripeness. If hand sorting has been well performed either at the collection site and/or at the wet mill stage, further sorting before pulping is likely not required. However, if volumes at the wet mill are high or the owner wants to add another quality step, size or density sorting can be performed. Size based sorting at cherry stage, which is needed if cherry material is not clean, can be done by mechanical sifters which could be used at the start of the pulping machine line. Shifters shake the cherries on perforated screens with large hole size to let all cherries go through while larger matter stays behind (stones, twigs, etc.), and fall on a smaller perforated screen which only lets through matter smaller than cherry (small stones, underdeveloped cherries, sand etc.), while cherries proceed to the main outlet. In addition, a fan blows lighter impurities out. Density based sorting of coffee cherry is done through hydraulic separation. By submerging cherries in water, the ripe and under ripe cherries will sink to the bottom, while dried, insect-infested, improperly developed, and low-density cherries float to the top. Light, extraneous material, such as leaves and twigs, will also float to the top. This is not a method for separating based on ripeness. Next to taken out defects related to lower density and dried out cherries, an added

[15] or mechanically through the use of an optical color sorter though extremely rare in East Africa

advantage is that the water cools down the cherries and standardizes cherry temperature before fermentation. Hydraulic separation can be done mechanically or manually.

Mechanical hydraulic separation can be achieved through syphon tanks or more advanced machinery (as seen in the pictures below). Syphon tanks tend to be water intense, and a circulation pump should be added to limit water usage; however, even then, it is still not an eco-friendly solution. More advanced hydraulic separators are efficient and effective for processing lines that are handling large volumes of coffee cherry.

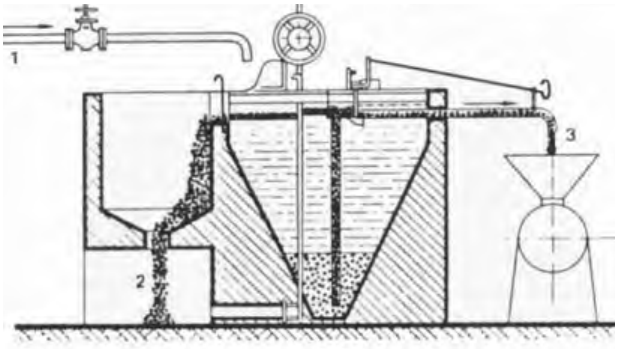
Manual hydraulic separation is typically done with the use of a bucket or tank of water where coffee cherries are floated to remove the light and low-density materials.

The decision on whether to invest in cleaning equipment depends on a) quality and consistency of raw coffee cherry material received; b) the type of pulping machine and processing employed; and c) size of the wet mill. See the decision tree below to determine what machine best fits a wet mill's needs. Note that the better cherry quality and purity can be managed at the farm level, the less there is a need for a wet mill to invest in cleaning equipment, if at all.

**Figure 10: Hydraulic separation examples**

Manual Hydraulic Separation

Mechanical Siphon Tank




Advanced mechanical hydraulic separator

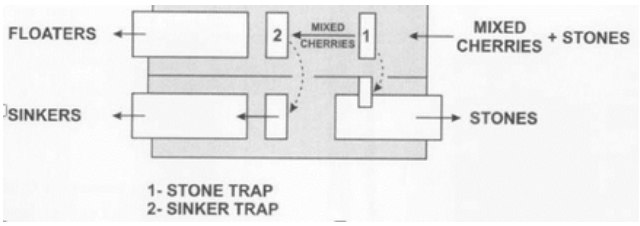
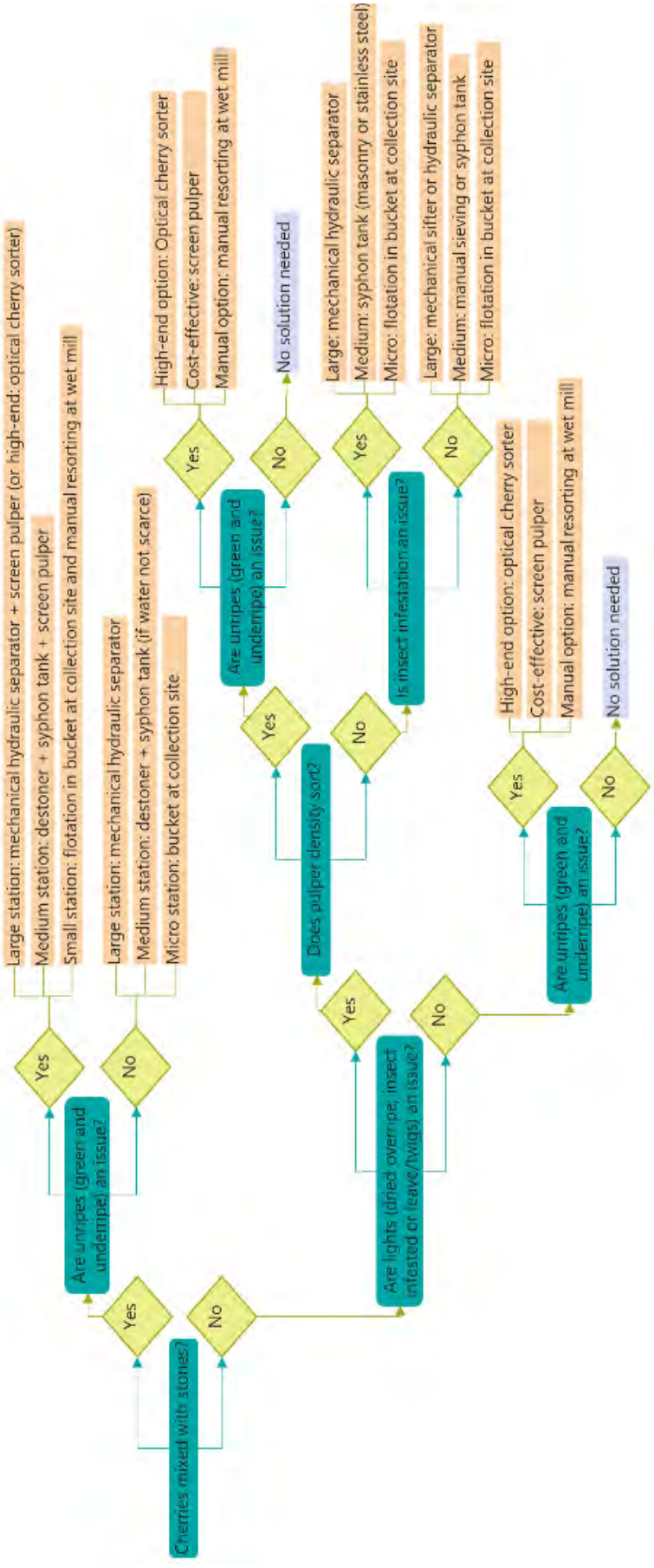
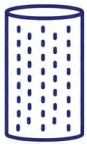
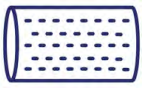



**Figure 11: Pre-cleaning flow chart based on conditions of raw material**



## Pulping Equipment

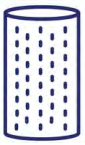
Currently, there are three main types of coffee pulpers:

| Disc pulper | Drum Pulper | | Screen Pulper |
|---|---|---|---|
|  |  |  |  |
| • High Capacity<br>• Can provide separation into different coffee grades<br>• High water and power consumption<br>• As discs wear down, insufficient separation of pulp and parchment coffee<br>• Most damaging to coffee | • Lowest power and water consumption<br>• Most efficient<br>• Allows for adjustment based on coffee size<br>• Most common design for ecopulpers<br>• Calibration adjustments can be difficult | • Ability to pulp coffee cherry of multiple sizes<br>• Can be used with minimal amounts of water<br>• If mixed maturity raw material, can cause significant damage to coffee | • Only technology with ability to pulp based on ripeness<br>• Low water consumption<br>• Must be used in conjunction with another pulper<br>• Inability to separate pulp from pulped coffee |

### Disc Pulper

This is the most common technology found in East Africa. It separates the parchment coffee from the pulp by squeezing the coffee cherries against a rotating disc. This is the oldest technology, most likely to cause damage to the parchment coffee, and has the highest water and power consumption (CQI, 2019).

- If using a disc pulper, parchment coffee is graded into three grades – Parchment 1 (A grade), Parchment 2 (B grade), and Parchment Lights (C grade) – by density and size of the coffee. Parchment is conveyed to the fermentation tanks while any un-pulped or semi-pulped cherries are taken through another smaller pulper called a re-passer to remove any skins left on the parchment and channeled to a separate Parchment 2 (or B grade) tank to ferment.



### Drum Pulper

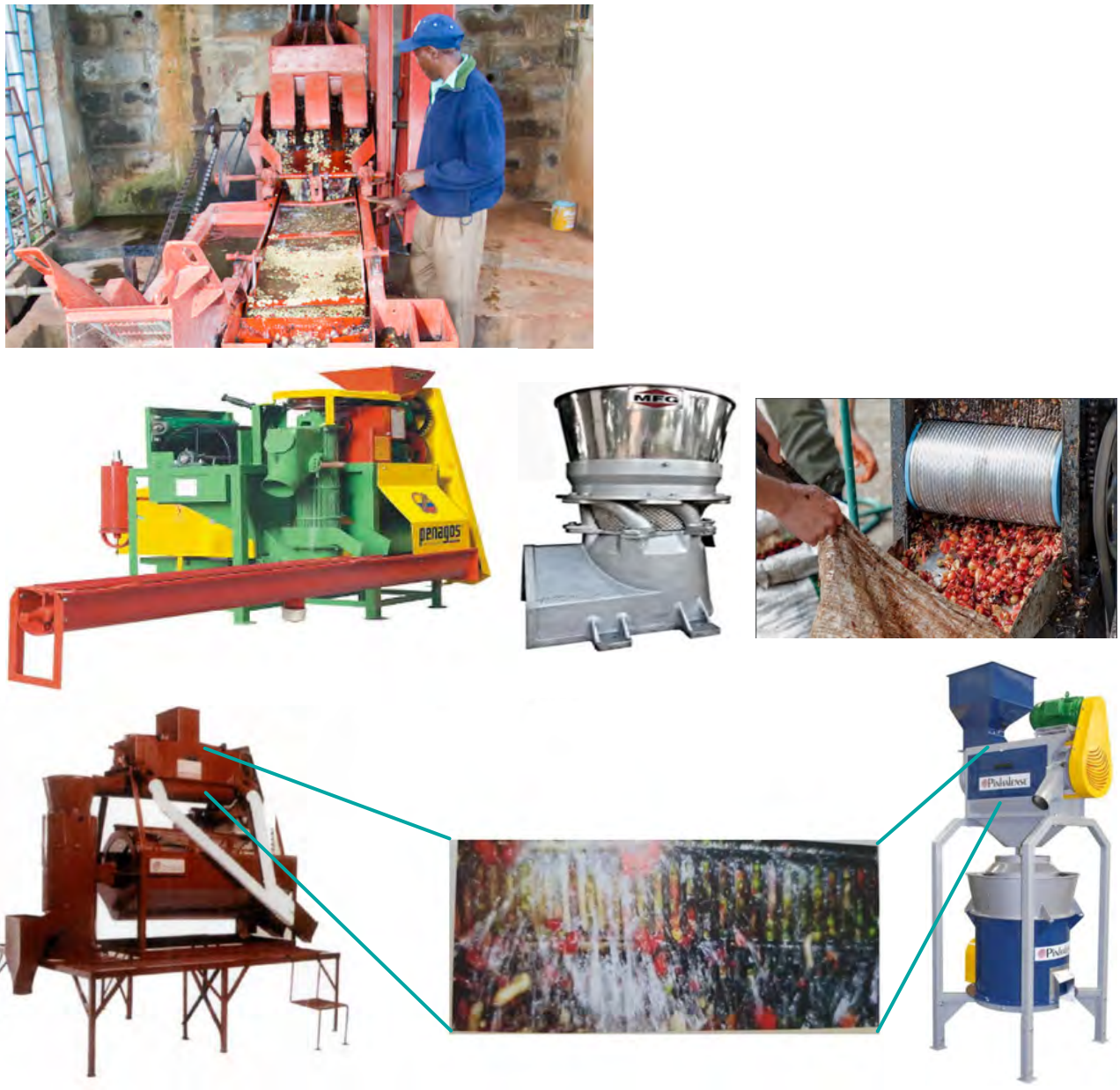
A vertical or horizontal drum pulper uses minimal water to pulp the coffee cherry by forcing them between the outside of the drum and a breastplate. Both a vertical and drum pulper allows for pulping coffee fruit of multiple sizes; a vertical drum pulper does this most efficiently. However, while pulping all sizes is good for outturn ratios, it is not necessarily positive for quality as it does not let underripes or green cherries pass through unpulped. Some of these pulping machines are combined together into a single unit that includes a built-in mechanical demucilager that removes the mucilage. These are often called “Eco-pulpers Units” and include the actions of pulping, mucilage removal, and washing done at the same time.

- If using an “Eco-pulper Unit,” the pulped parchment goes through a cylindrical sieve to separate pulped coffee from unpulped cherry before it goes to the attached mechanical demucilager where the coffee enters the bottom of the machine is moved upwards via a screw auger and water. Friction with the outside grill, rubbing against each other, and water inside the chamber removes the mucilage and drops it to the bottom (and into the discard pulp screw conveyor) while parchment comes at the top, washed. As pulping happens in the evening, the washed parchment is left to dry in fermentation tanks until the morning. It is advised to manually wash the beans before taking them to the skin drying tables to make sure all mucilage has been removed and any remaining floaters as well.

## Screen Pulper

This is one of the newest technologies where pulping is achieved by pressing coffee cherries against a screen perforated with elongated holes. It leverages the principle that coffee cherries soften as they mature allowing for the use of less pressure to pulp them. Due to this change, ripe cherries will easily pass through (together with the separated pulp) while unripe harder cherries will stay behind channeled to a separate outlet for unpulped cherries (unripes). The pulp and wet parchment is then separated by passing through a subsequent drum pulper. While uncommon in East Africa, if underripes pose a large challenge, a screen pulper is a cost-efficient solution. However, these are not as widely available as the other two pulper types as it is a relatively newer technology.

**Figure 12: Disc pulper with grading system in operation (top), eco-pulper with a vertical drum pulper and built-in demucilager (middle left), vertical drum pulper unit (middle middle), the back of a horizontal drum pulper in operation (middle right), Two models of screen pulpers with a vertical drum pulper after the screen pulper (bottom left [16] and bottom right) with close up of screen pulper in operation (bottom middle)**




[16] P.626 of Wintgens, Jean Nicholas (2012), Coffee: Growing, Processing, Sustainable Production, Second Revised Edition, Wiley-VCH publisher.

## Pulping Guide:

- Water quality and availability – pulping water should be clean. Ensure the water is adequate to pulp and wash all the parchment coffee processed for the day. As much as possible, limit the amount of water used during pulping.
- Ensure the pulping machine has been serviced and is in sound working condition. The engine should be well maintained; if using electricity, ensure to have a back-up generator in case of power failure.
- Clean the pulping machine well before beginning to pulp cherries; check to remove any left-over parchment or cherries from previous pulping, these become defects (like sour beans or stinkers) and lower the quality.
- If recirculating water, ensure the recirculation pump is in good working condition.
- Pulping machine settings and adjustments are done according to harvest progress and cherry ripeness. For example, size variability could be higher at the start and end of the season which requires adjusting settings to avoid nipping of beans.

## Before Beginning to Pulp:

- Check that the water flow is consistent.
- Check that the hopper valve is working well and controlling the amount of coffee cherry getting into the machine for pulping.
- Check that the density sorter is moving well and re-passer is well calibrated (a bit tighter than the main discs).
- Check all belts for correct tightness.
- Check oil and fuel levels. Use clean petrol from pump stations (buy enough to avoid late purchases from rural shops that mix fuels and sell at high prices). When adding petrol, turn off engine and allow to cool for two minutes before opening fuel tank. Fill fuel tank with petrol and allow 1-inch space over the tank and fuel cap (do not fill completely).
- Ensure there is enough cherry in the hopper to begin pulping.
- Determine the correct machine settings by pulping some cherries to observe the pulp fully separates from parchment and the beans are not broken. Adjust the pulper settings as appropriate.
    - The pulping machine is too tight/narrow if it is breaking the beans or nipping the parchment off the beans resulting in naked/white beans– use a bic pen to adjust the space between the disc and the chops (disc), between de drum and screen or plate (drum), or adjust the counterweight (screen) depending on which pulper is being used.
    - If there is pulp and unpulped cherries in parchment, then the pulping machine is loose/wide – use a hacksaw blade (same thickness as the coffee pulp) to adjust the space between the disc and the knives or reduce space between drum and screen/plate or reduce counterweight.
    - In case of using a disc pulper and there remains lots of skin/pulp in the parchment, then either the discs are worn out and should be taken for spraying/sharpening, or the water feed was too low.
- With every hopper/bin of cherries loaded, if the un-pulped cherries being sifted out are more than 10%, readjust the breastplate, screen, or chops accordingly.
- After loading one bin of cherries, look at the pulped output, and randomly inspect 50 beans. Unpulped coffee fruit should be kept below 10% (no more than 4 beans) and white or cracked beans below 5% (no more than 2 beans), otherwise re-calibrate.
- In addition, monitor the amount of pulp skins inside the parchment coffee and the number of parchment coffee inside the coffee pulp output. If no beans are coming out with the pulp at the back and only minimal pulp or unpulped beans (<10%) is coming out with the beans in the front, then proceed with pulping until all the coffee is pulped.

# Disc pulper troubleshooting guide

**1. Sharp noise from discs while pulping-**

a) Check whether during calibration the chop and disc were set properly to avoid them grinding against each other.
b) Check if there is a stone or metal trapped in the cherry hopper and remove.
c) Check whether the following are loose. The disc, disc guard, the chops, or the cherry hopper and tighten properly
d) Check the bearings are worn out or loose by pulling and pushing the disc shaft from t he side
e) Check if disc is warped and needs replacement

**2. Machine output during pulping is low.**

a) Check the motor is of correct capacity and set at the correct angle to reduce a lot of friction.
b) Check the slots are well fixed and not closing the passageway for the cherry.
c) Check the disc surface is smooth or rough and respray the discs if smooth.

**3. If there is too much pulp in parchment**

a) Check the disc surface is smooth and worn out - respray or replace with one with rough surface.
b) Check the calibration of the disc against the knives with the hacksaw blade.
c) Check calibration of the discs and the angle plate - calibrate the right gauge

**4. Machine breaking/nipping beans**

a) Check calibration of the disc and the angle plate using the right gauge
b) Check the nylon fingers are worn or the nylon rubbers are rigid and if so replace

5. **A lot of cherry passing out unpulped -**

Check whether the nylon fingers are loose and calibration is done well.

**6. Presence of many broken/whole beans passing out with pulp**

a) Check the calibration of the disc and the angle plate
b) Check the calibration of the nylon fingers

**7. There are unpulped small berries and pea berries in parchment**

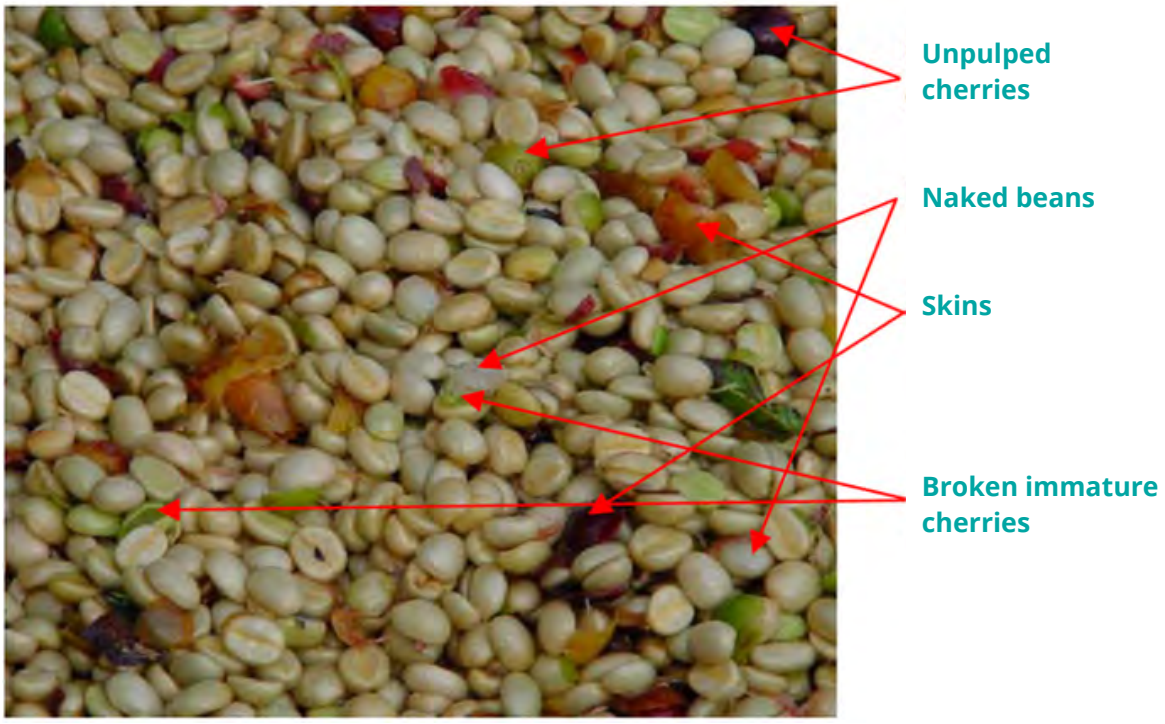
a) Check whether the pre-grader sieve is of the right size
b) Check whether the volume of water and speed is correct

For a video on troubleshooting **click here** (link will be added in future)

For a video on pulper maintenance **click here** (link will be added in future)

**Figure 13: Example of good pulper output on the left and bad pulper output on the right (setting too loose resulting in too much pulp exiting through the parchment outlet)**

**Figure 14 : Example of pulper output with multiple defects [17]**




[17] Module 3.2 'Design issues: Pulping equipment', p3 in "Good Hygiene Practices along the coffee chain: a training resource for coffee producing countries, Food and Agriculture Organization of the United Nations (FAO), 2006."

## During Pulping:

- Make sure to start and finish pulping on time and stick to the same hours each processing day. Both the time between harvest and pulping (six hours) as well as the time between when the first parchment fills the tank to the last parchment is added to the same batch (one hour), should be minimized to keep processing conditions uniform. Delays in processing after harvest can lead to uncontrolled fermentation within the fruit. Delays during pulping that slow the filling up of the tank can lead to uneven fermentation.
- Pulping should begin by late afternoon or as early as practically feasible during peak processing days.
- Control flow of cherries into the pulping machine.
- Strive for a balance of engine speed, drum/disc/screen rotation, and cherry intake by adjusting the engine throttle and the cherry hopper valve; avoid running the engine at full speed.
- When processing large volumes of cherry, if the speed of the engine, drum/disc/screen rotation, or parchment output slows dramatically, then this means the pulping machine is overloaded. First, increase the engine speed using the throttle. If this does not work, then reduce the cherry intake by lowering the flow valve on the cherry hopper. Record ideal settings once optimized for later reference.
- A McKinnon disc pulper machine will mechanically separate heavies (fully pulped parchment) and lights; the lights should be re-passed through the pulping machine at the end of the day or processed separately using a hand-pulper.
- Ensure the parchment is directed to the correct fermentation tanks to avoid mixing parchment grades.

## After Pulping:

- Record the date and time that fermentation has started (when tank is filled).
- Clean the machine immediately after each pulping session (do not use soap) to remove any trapped beans, skins or other waste; failure to do so may slow machine output and introduce “stinkers” that reduce quality.
- Check for any water leakages into the fermentation tanks while the coffee is fermenting; this can lead to inconsistent results.

## At the End of the Season:

- If using a screen and/or drum pulper, ensure screen and drum are thoroughly cleaned with a hard brush so no organic material remains stuck anywhere. Then apply food grade oil (e.g., coconut oil) with a soft cloth to prevent rust.
- If using disc pulper, spray and assemble any worn-out discs or drum screens to be ready for the following season. Check that they are correctly assembled and not on reverse orientation; each disc has an arrow which points forward if assembled correctly.
- Replace any worn out knives and chops.
- Replace any worn out belts and chains.
- Repair or replace any broken parts.
- Wash and paint machine parts.
- If using a diesel or petrol engine to drive the pulping machine, conduct routine maintenance, replace oil, and replace filters to be ready for the next season.

## Disc pulper calibration guide:

1. Set the gap between the disc and knives:
    - Loosen the bolts attaching the pulper bar to the pulper
    - Set the distance between the two so it is the width of a hacksaw blade and make sure the width is the same on both sides.
    - Retighten the bolts
2. Set the gap between the breast and disc:
    - Check that the gap is 4-mm using a 4-mm gauge tool
3. Set the gap between the disc and chops:
    - Check that the gap between the disc and the chops is 8-10mm (size of a coffee bean with mucilage on) using a ballpoint pen as a measure.
4. Make sure belts have the right tension.
5. Rotate the disc by hand listening for ringing sounds which would indicate that part of the chop is touching the disc.
6. Load the cherries and pulp.
7. Check the output:
    - Parchment should not be nipped (white/naked beans) or broken (<5%)
    - Amount of skins and unpulped cherries in the parchment should be less than 10% of parchment.
    - For a video on how to calibrate a disc pulper **click here** (link will be added in future)

# 3. Mucilage Removal

## Wet Mill Processing Stages

Cherry receipt

Pulping

Mucilage removal

Washing

Drying

Storage

After pulping, parchment coffee has mucilage intact and presents a decision to the processor: dry with mucilage intact or remove the mucilage. Mucilage removal is the process of mechanical or biological removal or "loosening" [18]of the mucilage.

- Mechanical - Through the use of a mechanical demucilager, the mucilage is removed through friction, force, and/or high-powered water.
- Biological - Through relying on microbial intervention, the mucilage is loosened through the fermentation processes.

Traditionally, processors relied on the biological process, mainly fermentation, to loosen the mucilage in order to wash it free. Fermentation can occur throughout the entire process from coffee cherry on the tree to fully dried parchment coffee; therefore, it is important to understand the goal of fermentation used during this step and what one is attempting to achieve. There are two main goals processors are attempting to achieve through mucilage removal

1. Successful removal of mucilage, while minimizing damage to the coffee seed as well as development of defective flavors
2. Developing specific or unique characteristics of flavor, aroma, etc. to the resulting coffee seed.

[18] In the biological process, this step in processing involves the breaking down of the compounds that hold the mucilage to the parchment to be able to wash it clean in the following step.

Understanding the specific goal one is attempting to achieve provides clarity and serves as a key decision point for the wet mill. As an explanation of these two goals and how it impacts decisions, consider the two examples below:

- Wet Mill A is a large volume wet mill processing 10 MT of coffee cherry per day. They have a consistent buyer of their coffee who is looking for an 83 to 84 point, clean, consistent coffee. The client purchases this coffee on a differential basis and commits to purchase 75% of Wet Mill A's coffee, as long as it meets this specification. The margins are tight, so the wet mill works to keep their expenses low. The quality control team has discovered that they can use an Eco-pulper unit (pulper, mechanical demucilager, washing all in one) and hit this quality target. Instead of taking on the additional risk of defect development that biological removal through fermentation brings, they decide to use mechanical mucilage removal and focus their efforts on drying standards and raw material selection.
- Wet Mill B is a smaller, cooperative owned wet mill processing about 4 MT of coffee cherry per day. Their market is focused on producing unique, individual smaller lots of coffee quality that targets the specialty coffee market. They decide to use biological removal of mucilage through different fermentation techniques to develop these kinds of flavors. They still must rely on monitoring raw material, managing fermentation, and ensuring drying is consistent, but because they are targeting higher revenue markets, they can justify the higher costs.

Neither of the two above illustrations are right or wrong. The approach and goal must be tailored to each individual situation with all factors considered together. Below is a guideline on recommendations for each (mechanical and biological) process to consider.

## Mechanical Mucilage Removal

There are two main types of mechanical mucilage removal technologies: upward flow demucilager and centrifuge[18]. The Upward Flow demucilager is the most common; therefore, the following recommendations will focus on using this technology.

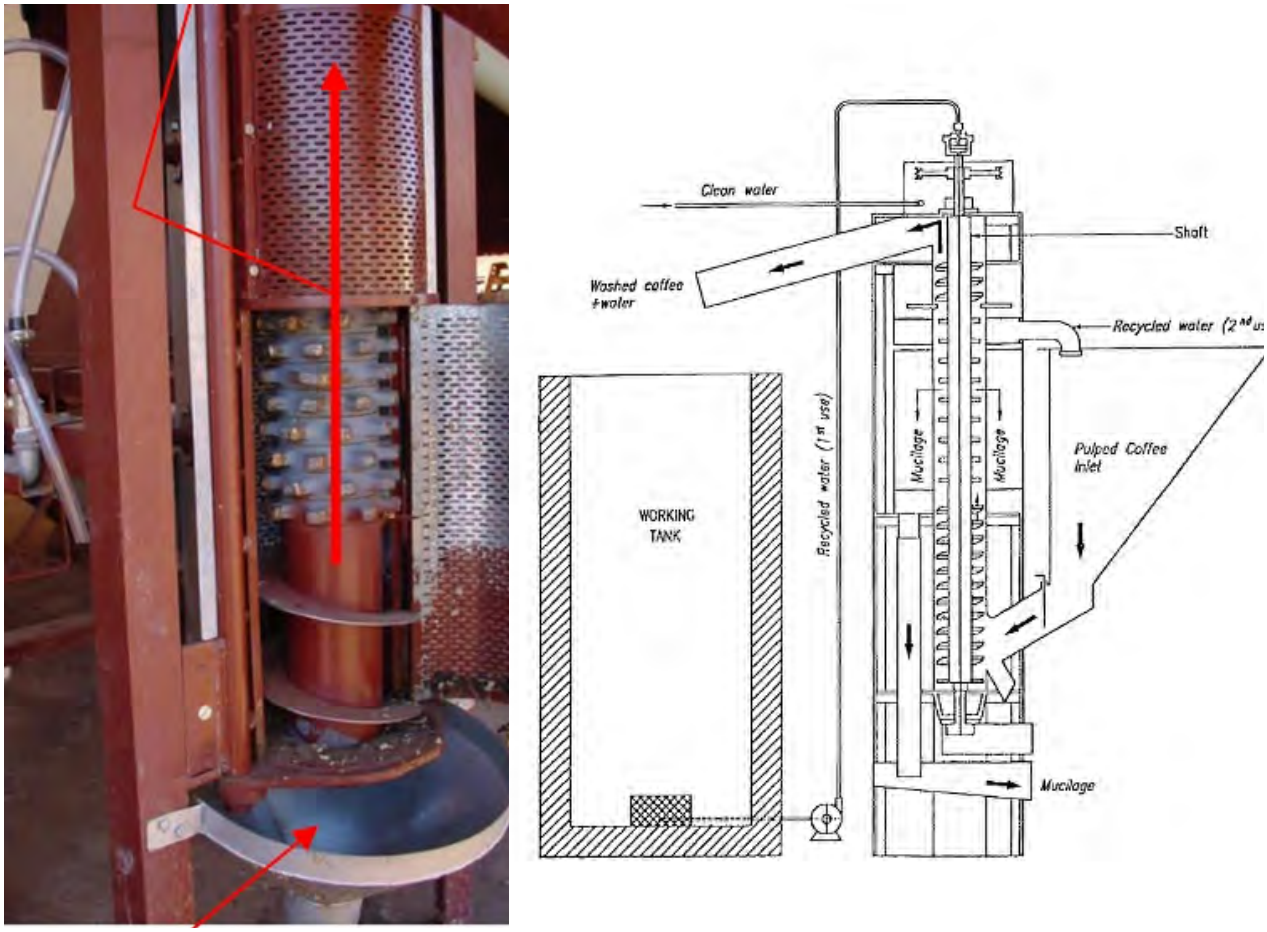
**Figure 15 : Photo on the left shows an ecopulper with demucilager in operation, in the middle a a close up view of a demucilager and its tightness setting handle, on the right a close up of a demucilager in operation [19].**

[19] This technology seems very promising as it provides for mechanical removal while limiting the risk of damage to the coffee seed. However, they are not prevalent in the market at this time.

The Upward Flow Demucilager operates under the principles of using friction and pressurized water to force the mucilage to be separated from the parchment coffee. Parchment coffee with mucilage intact enters the bottom of the machine and is forced upward. The clean parchment comes out at the top and is ready to move to the drying section. (Please note that most units provide an option to remove partial amounts of mucilage and there still presents an opportunity to utilize a mechanical mucilage remover to wash a portion of the mucilage off and then allow biological processes through fermentation to loosen the remaining. This will depend on the goals each wet mill is attempting to achieve in this processing step).

Some pulping machine units (e.g. Eco-Pulper Units) come with a pulper, rotating sieve (for separation of pulped and unpulped coffee cherry), and a mechanical demucilager all together with a very small and efficient footprint. Additionally, mechanical demucilagers can be purchased separately and placed anywhere on the processing line [20]. Though it is common to find disc pulpers throughout East Africa, a mechanical demucilager can be added to this kind of processing line as a stand-alone unit. When using a mechanical demucilager consider when density sorting takes place; either during pulping or as part of pre-cleaning (if pulper does not have hydraulic separation as part of its line up).

**Figure 16 : Photo on the right showing the outside view with arrow showing the mucilage reception area and an upward arrow showing the direction of the flow, On the left a sketch of an upward flow demucilager [21] [22] .**




[20] There is a current trend in coffee processing to position the mechanical demucilager AFTER the fermentation tanks to utilize this technology to wash the mucilage AFTER fermentation loosens the mucilage. This reduces labor, time, and cost of running density/washing channels.
[21] Wintgens, Jean Nicholas (2012), Coffee: Growing, Processing, Sustainable Production, Second Revised Edition, Wiley-VCH publisher.
[22] Module 3.2 'Design issues: Pulping equipment', p4 in 'Good Hygiene Practices along the coffee chain: a training resource for coffee producing countries', Food and Agriculture Organization of the United Nations (FAO), 2006.

## The Advantages of Using an Eco-Pulper Include:

- Up to 80% reduction in water use
- Coffee does not lose any mass during the fermentation process [23]
- Lower infrastructure and labor costs (only small space required, fewer fermentation tanks and no grading channel)
- Improved consistency between lots
- Reduction in risk of defects caused during fermentation

## Disadvantages of Mechanical Demucilagers Include:

- Higher upfront machine investment
- Shorter machine lifespan
- More risk of mechanical damage to the bean (risk can be reduced by proper machine calibration)
- Power requirements of the equipment
- Fewer opportunities to play with the effect of fermentation on flavors within the cup profile

## Operating an Upward Flow Mechanical Demucilager:

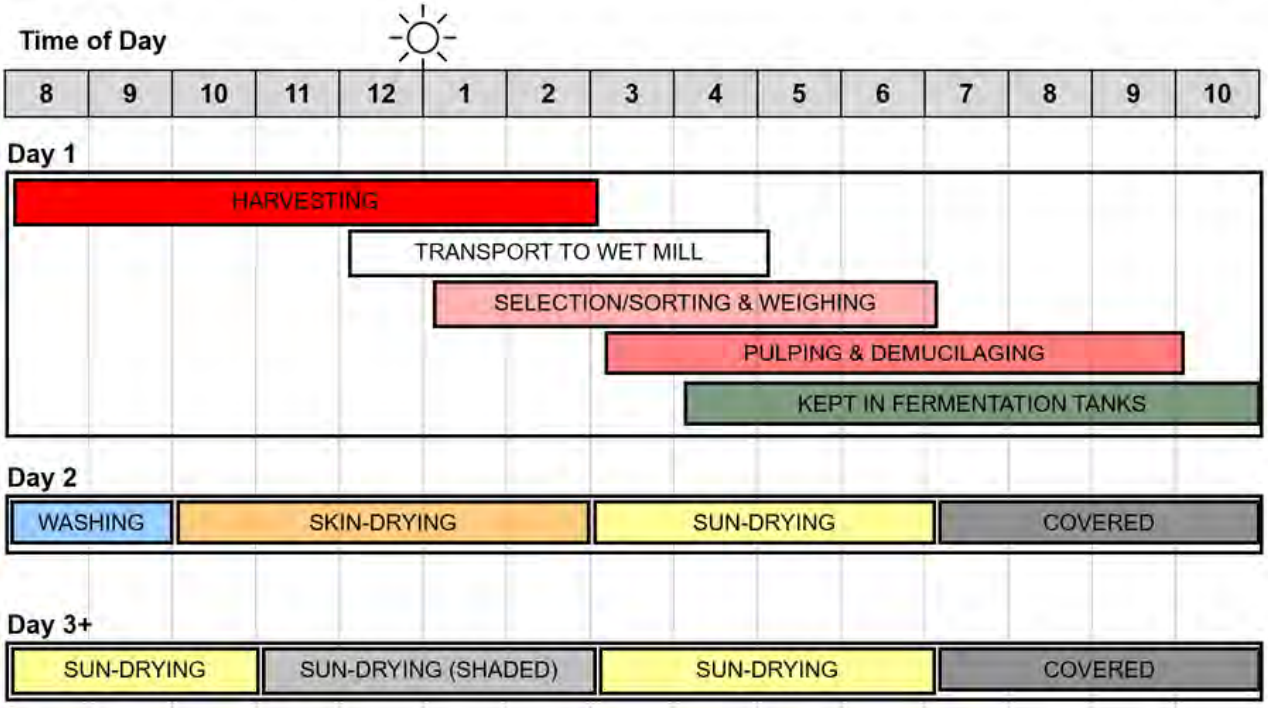
- Pulper will mechanically feed the parchment into the bottom of the mechanical demucilager chamber.
- Demucilager will convey the parchment upwards, applying friction and pressurized water to the parchment to remove mucilage.
- Clean water is delivered to the system through small pipes positioned along the mechanical demucilager chamber to wash off the mucilage.
- Mucilage will be excreted from the chamber and into the mucilage channel, which should join the pulp waste channel.
- The first 15 kg of parchment to exit the unit should be re-passed back into the mechanical demucilager. A key aspect of these units is that they must be run at full capacity; therefore, the first 15 kg of coffee passes through the chamber too quickly and does not have a chance to have complete mucilage removal [24].
- Brush the demucilager sieves from the outside after every hour to prevent clogging. If coffee coming out of the unit is very slimy to the touch, this means sufficient mucilage is not being removed. The residency time within the chamber needs to be extended, therefore, adjustments to the pressure of water and/or delivery speed into the unit must be adjusted.
- If coffee coming out of the unit is damaged (i.e. white beans or broken), then the coffee is remaining in the chamber too long and the speed through the machine must be increased.

[23] "Coffee loses around 1% of its dry material during fermentation and some soluble substances are leached. The partial loss of some compounds can improve coffee quality by reducing astringency and bitterness in the cup." (Meia Borem, Flavio, 2014, Handbook of Coffee Post-Harvest Processing).
[24] This is an important consideration when deciding if this technology is appropriate for your situation. In order to be effective, these machines need to be run at full capacity and have enough volume built up to justify its use. If processing small microlots (such as less than 500 kg), a mechanical demucilager might not be the most efficient option.

## When Operating an Eco-Pulper Unit with Built-In Mechanical Mucilage Remover, the Standard Timeline is the Following:

Evening – pulp coffee cherries delivered that afternoon and pass through the mechanical demucilager.
Night – leave the parchment overnight in a fermentation tank to wait for next day processing.
Early morning – wash the parchment in the tank to ensure all mucilage has gone and move to the skin drying tables for sorting (while still wet). The wet parchment should be washed and on the skin drying tables by roughly 10 am in the morning.

**Figure 17: Estimated timeline when using a drum pulper with mechanical mucilage removal**




## Biological Mucilage Removal: Fermentation

The biological mucilage removal process relies on fermentation to loosen the compounds holding the mucilage to the parchment to allow for washing it off. This is a complex process that continues to be an area of innovation, research, and experimentation to better understand and control. The time required for loosening of mucilage can vary widely depending on the ambient temperature, thickness of the mucilage, microbe population, water quality, and more. Lower temperatures might draw out this process causing dormancy as microbes reduce activity and a fermentation could “stall” (higher risk with the submerged method). Conversely, higher temperatures might speed up a fermentation and cause a "runaway" fermentation that is difficult to monitor and can kill desirable microorganisms or activate those hazardous to health or develop undesired flavors (higher risk with the dry method). Monitor therefore the temperature of the parchment during fermentation (ideal temperature between 20-25 degrees) and try to regulate day and night temperatures.

There are two main methods used for fermenting coffee: dry and submerged. Dry fermentation occurs when pulped coffee is placed in a fermentation tank or vessel without water and allowed to break down. Submerged fermentation involves the addition of clean water to the fermentation tanks and allowing the process to occur underwater. Each method will produce different results, has its own strengths and weaknesses, and must be evaluated against quality control and costs analysis data.

**Figure 18: Fermentation tanks (left) and fermenting coffee (right)**

## Submerged Method

Of the two methods, this utilizes the most water and requires sufficient volumes of water for fermentation and washing. Water has its own microbial load and depending on the level of consistency or cleanliness of the wet mills' water source can be a source of inconsistency across batches during a season. In addition, soluble compounds present in the coffee can dissolve in water and could produce milder or reduced complexity in the final cup [25]. On the other hand, in areas of high temperatures (like those close to the equator and at low altitudes), submerged fermentations allow for greater control of temperatures and management of the fermentation process. In addition to serving as a refrigerant, water serves as an efficient medium for movement of microbes within the tanks to help promote consistency of fermentation. Apart from hot regions where elevated ambient temperatures need to be controlled and at wet mills without shade covering tanks, it is not recommended to use the submerged fermentation method.

**Figure 19: Submerged Method (left), Dry Method (right) [26]**

## Dry Method

This method is a great option in areas with reduced access to high volumes of water. It is important to note that the fermentation process produces heat as a by-product. As such, dry method fermentations should not occur exposed to direct sunlight as this can cause out of control fermentations. Without a medium like water to encourage consistency of fermentation, dry method fermentations must monitor closely the volume of coffee being put into a tank and strive for consistency between batches. Though this method uses comparatively lower volumes of water, it requires careful attention to ensure consistency.

[25] This could be a positive characteristic and must be evaluated against sensory results to make the best decision.
[26] Doctor Vannostrand

## Control Points of Fermentation Process

If using fermentation to loosen the mucilage and impart flavor characteristics to the final cup, it is essential for wet mills to monitor the progress of fermentation to ensure consistency. The "washing point" defined as the point when the fermentation process is stopped by the washing of the mucilage free from the parchment must be decided through a combination of several key factors. If the coffee is "under-fermented" the mucilage will not be appropriately loosened and require extra time and work to wash clean. On the other hand, if fermentation is allowed to progress too long, the risk of undesirable characteristics and potential for defects is higher. The key is to be consistent between batches. The factors to consider when defining the washing point are:

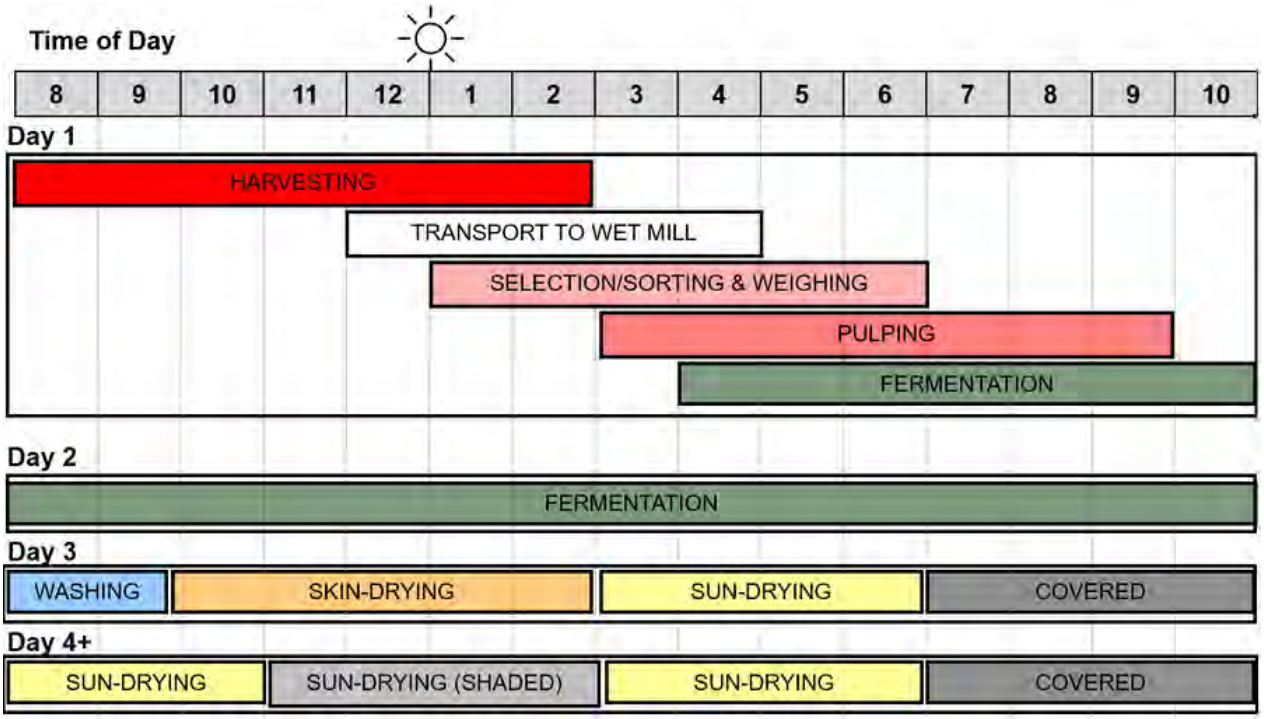
1. pH. During the fermentation process, the pH of the system will drop as organic acids are produced. This can be measured by using a pH meter. However, the final pH number should not be used as a definitive determining point for the washing point. Coffee fermentations will begin around 5-6.5 pH depending on starting pH and water medium. They will drop by roughly 2-2.5 points during fermentation. However, these values vary per area. pH levels can be impacted by the starting pH of the coffee entering the tanks, type of water used, ambient conditions, etc. This data point should be used in conjunction with the below points to make a washing point determination.
2. Feel. Fermentation has a goal of loosening the mucilage from the parchment. At the beginning of fermentation, one can note the slimy and slick nature of the parchment coffee. As the process progresses, the parchment coffee begins to feel gritty and might resemble rubbing wet stones together. This is a good indication that the mucilage has loosened. If in doubt, one can always grab a sample, and wash with water to check. Alternatively, drive a broom stick into fermenting parchment and pull it out in one stroke leaving behind a hole. Fermentation is complete if the hole does not collapse. If the hole collapses (caves in) then the coffee should be left to ferment a little more.
3. Smell. The fermentation process produces a host of aromatics. Some of these are positive and some are negative. While this should not be used as a determining factor alone, if smells of vinegar (acetic acid) or overly pungent alcohol are present, this can indicate the fermentation is at risk of negatively impacting the coffee. Encourage staff responsible for monitoring fermentations to write descriptors of what they are smelling
4. Time. Similar to pH, this is not a strict standard. Setting a standard time (i.e. 12 hours precisely) for fermentation and holding to this will create inconsistencies between batches as the changing ambient environment will create variations in the process. One should use time as a general guide and indication to arrange workflow; however, attention to all three of the above factors should be considered.

## General Guidelines for Biological Removal of Mucilage through Fermentation

- Clean fermentation tanks thoroughly before receiving parchment; check and remove any parchment from previous fermentation. Unclean tanks will influence the fermentation process and encourage inconsistencies. Be sure to also check screens and drain pipes for any lodged parchment when cleaning.
- Use clean water for pulping and transporting parchment to the tanks.
- Use different fermentation tanks for different parchment grades and label the tanks for parchment traceability.
- Do not mix parchment pulped on different days or different grades in one fermentation tank.
- Pulping and transport water can cool down the coffee mass as well as slow down fermentation. During fermentation do not allow any water (e.g., by not fully closing the tap) into fermenting coffee as this slows down the process, until the coffee is ready to be washed and water is used to transport the coffee from the tank to the washing channel.
- The temperature of the coffee should be monitored. If temperature is too low, the growth of microorganisms will decelerate. If the temperature is too high, it could impact coffee quality. Keep coffee mass temperature between 20-25 degrees (if temperature exceeds 40 degrees microorganisms will begin to die). Therefore, shade is important during the day (through a roof above the tanks) and during the night the tank can be covered with a plastic sheet to retain heat.
- Ensure parchment coffee entering the fermentation tanks is uniformly pulped. This should not have skins and un-pulped or partially pulped coffee.
- Prevent rain from entering the fermentation tanks.
- Check fermentation regularly for completion. Once fermentation is complete, wash the coffee immediately. If it is too late in the night and not possible to wash, then put parchment under water (if dry fermentation) or drain tank and flush parchment with fresh water (if submerged) to slow fermentation and wash early the next day [27].
- If pulping or fermentation protocol is not followed as normal, for whatever reason, it is advised to make note of the circumstances and keep the day's lot separate. After cupping it can be decided whether or not to bulk it together with other day lots of coffee.

[26] Note: The process of soaking involves submerging coffee underwater for an extended period of time. This will have the result of dissolving additional solubles inside the coffee seed. The quality impact will vary; however, as a rule of thumb this should not be done for longer than 24 hours.

**Figure 20: Estimated timeline when using a disc pulper and biological mucilage removal (ferrmentation)**




## Maintenance of Fermentation tanks and washing channels.

- At the end of the season, repair the fermentation tanks and the washing channels, sealing any cracks and damages sustained throughout the season.
- If the surface of the tanks is tiled, then replace any worn out or broken tiles.
- If the tanks and washing channel have concrete surface, use epoxy paint to repair and paint the worn-out surfaces and cracks.
- Make sure there is a roof built over the fermentation tanks to provide shade and regulate an even fermentation by avoiding direct sunlight and protecting against rain entering tanks.

**Figure 21: Repairs and maintenance of the wet mill facilities**

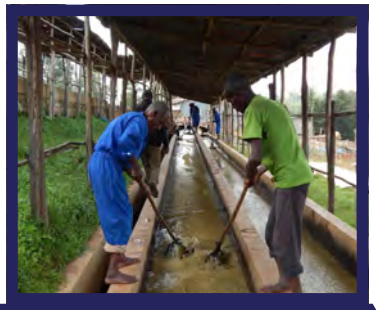
# 4. Washing

## Wet Mill Processing Stages

Cherry receipt

Pulping

Mucilage removal



Washing

Drying

Storage

When fermentation is complete, the coffee is immediately washed to remove the mucilage from the parchment surface. The coffee is then graded and ready to dry. This happens in the washing channel.

### Parchment Washing Guide:

- Clean the washing channel before washing coffee removing any dirt and parchment from previous washing. Check any cracks or crevices in the washing channel.
- Use clean water to wash parchment and ensure that there is enough water to wash coffee.
- Keep the floor of the washing channel smooth to avoid bruising the parchment during washing.
- Use a squeegee (rake) made of wood and rubber or a broom to wash parchment, do not use a hard brush as this will bruise the parchment surface.
- Construct the washing channel in a sloping fashion for efficient washing and grading. Wash the parchment by stroking the squeegee up the slope.
- Construct the washing channel with stoppers that help separate the parchment grades.
- Wash different parchment batches and grades separately.

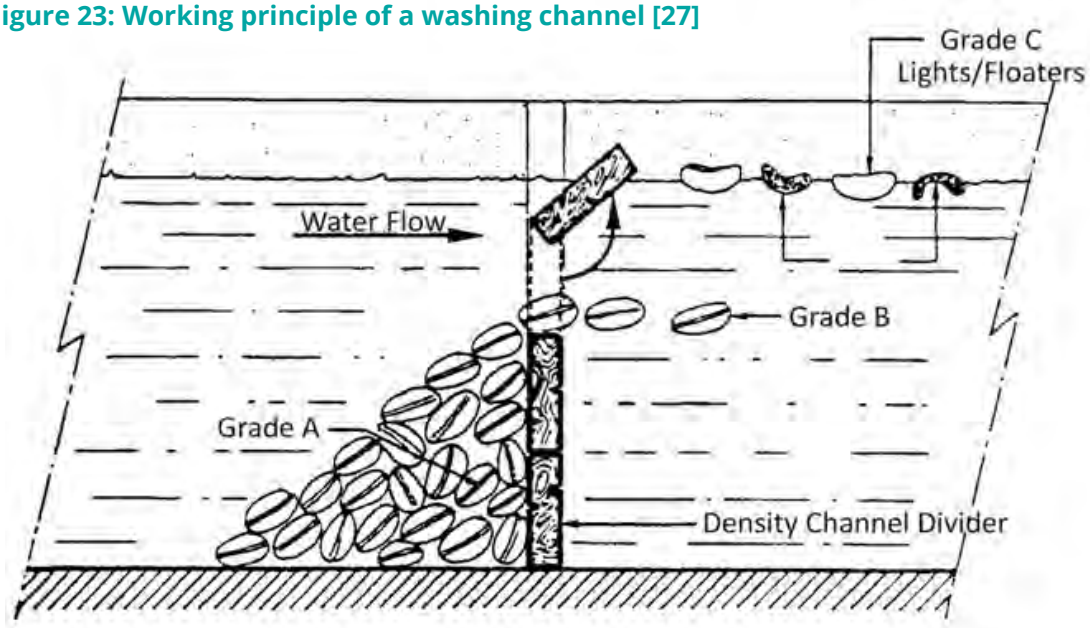
## Parchment Washing Process:

- Add clean water to the fermented coffee while agitating to loosen the mucilage and help push the coffee into the washing channel; open the valve to release the coffee into the channel.
- Open the taps to release clean water into the washing channel.
- Push the coffee against the floor of the channel using the squeegee in a stroking fashion up the slope, creating some friction between the beans and the channel. This washes the mucilage from the parchment surface. Repeat this process until the parchment surface is completely free from mucilage.
- If the wet mill does not have a washing channel, washing is done within the fermentation tank.
- Rinse the coffee until the water is visibly clean before moving the parchment to the tables for skin drying.

**Figure 22: Washing in fermentation tank (left) and parchment washing in a washing channel (right)**

While coffee is washed in the channels, it is being graded at the same time. Grading is aided by water in the washing channel; the water funnels the parchment, cleaning any residual pulp or skins present. There are three main parchment grades, Parchment 1 (Grade A), Parchment 2 (Grade B), and Parchment Lights (Grade C), based on density. Parchment 1 sinks and remains at the beginning of the washing channel while Parchment Lights float and move with the water to the end of the channel. The washing channel has stoppers to separate the parchment grades.

**Figure 23: Working principle of a washing channel [27]**




[27] Source: CIRAD-CP taken from Wintgens, 2012

**Figure 24: Channel grading (far left), Parchment 1 (middle left), Parchment 2 (middle right), Parchment Lights (far right)**

The highest quality is Parchment 1 (grade A) – these are dense and free from deformities, pest, and disease damage.

The next grade is Parchment 2 (grade B) – these are light beans and may have an anomaly in color due to pest or disease damage. In addition, they may be pulper damaged caused by poor calibration or increased presence of underripes when pulping.

The lowest quality is Parchment Lights (grade C) – these are usually light in weight due to drought, pests and diseases, and poor nutrition during production.

In some countries (like Kenya and the DRC), some wet mills put the washed parchment in soaking tanks for another 24 hours before drying. While soaking tanks can be used as waiting areas when skin drying tables or laborers are not yet available (e.g., washing finished at the end of the afternoon and workers have gone home) or used to soften harshness, it is generally not advised as a standard practice. When washing is performed well the mucilage will already be removed, so the step is not required and increases wet mill costs (longer processing time and potential bean weight loss) as well as impact cup quality.

**Figure 25: Wooden trays with mesh bottoms for transporting parchment to skin-drying tables [28]**

[28] 'Good Hygiene Practices along the coffee chain: a training resource for coffee producing countries', Food and Agriculture Organization of the United Nations (FAO), 2006.

# 5. Drying

## Wet Mill Processing Stages

Cherry receipt

Pulping

Mucilage removal

Washing

Drying

Storage

After the washing process is complete, the parchment is dried to reduce the moisture content of the parchment from approximately 57% to a maximum of 10-12% w.b. [29]. Drying should occur in a controlled, gradual and even manner. Drying too quickly can negatively impact quality. Equally, if not dried long enough on the drying tables or unequally dried, any beans that contain higher moisture content are susceptible to developing fungal growth during storage and reducing bean quality. Not just the coffee flavor and aroma profiles are affected by drying, it is also the coffee longevity. Improper drying can cause green beans to fade or age more quickly.

## Coffee Drying Methods:

### Sun Drying

Sun drying uses solar energy from the sun. Parchment is dried on concrete patios, tarpaulins, or raised beds. In East Africa, most coffee is dried on raised beds.

### Mechanical Drying

Mechanical drying using mechanical driers, common in large coffee estates.

[29] W.B. = wet basis. This is a measurement of water based on the total weight of the seed. Therefore, 10% moisture content w.b. means that 10% of the total weight is moisture.

**Figure 26: Sun drying tables (left) and mechanical drying (right)**


The two key parameters to monitor during drying are: final moisture content and bean temperature. Research is clear that once the bean temperature exceeds 40C the cellular structure begins to break down and both quality and shelf life is impacted. Therefore, it is essential that bean temperature be kept under 40C, and in fact, the best protocol would be to ensure parchment coffee does **not exceed 35C**. Monitoring this is done by the use of an infrared thermometer. It is the responsibility of those managing the drying tables to regularly check the parchment for temperature readings and when they begin reaching the maximum levels to turn the coffee.

## How to operate an infrared thermometer

To use the infrared thermometer, hold the device about 20-30 cm above the surface of the parchment, point the device at the pile, and click the trigger to initiate the reading. Make sure and take 5-7 readings located throughout the dry table and average them together. To monitor potential overheating of the coffee, it is best to take measurements at the end of the afternoon when the temperature inside the bean tends to be highest as the bean retains warmth (e.g., 4/5pm depending on weather conditions).

## Coffee Drying Stages:

- **Skin drying** stage starts immediately after the parchment is removed from the washing channel and should be done as fast as possible. During this stage, the parchment surface water is lost and the moisture content of the bean reduces from roughly 60% to 45%.
- **Final drying** stage starts once the surface water dries out and should be done slowly to attain gradual and consistent drying until the bean reaches 10%-12% moisture content w.b.

## Guidelines for Skin Drying:

- Ensure the skin drying tables are covered with a roof and are not exposed to direct sunlight.
- Ensure the staff are well trained, motivated, and compensated for their work.
- Ensure the drying tables are straight and not sagging, as this varies the depth of parchment on tables and prevents uniform drying.
- Clean the drying tables and remove any parchment from the previous batch to avoid contamination.
- Parchment on skin drying tables is handpicked to remove partially pulped, diseased, and damaged beans. If there are too many (>=1%) white beans from which the parchment have been removed during pulping, pulper calibration is needed. It is important to do this during the skin drying stage while the parchment is still wet from washing and defects are still visible. Insect-damage and unripe (green beans) will be apparent in the wet parchment; these beans should be picked out by hand and dried separately as 'low grade' together with lights/floaters. When skin table sorting is performed, no sorting on final drying beds needs to take place, unless looking for sun cracked parchment. Again, the better coffee cherry quality is managed at the farm level the less skin drying bed sorting is needed.
- The first days of drying are important to ensure coffee is able to begin drying as high moisture levels present a risk of mold and defect development. Turn wet parchment frequently by hand at regular intervals to ensure even skin-drying. Fix a chalkboard at the end of each table to record that coffee was turned. Continue turning parchment until no surface water remains; move parchment coffee to final drying tables (45% moisture content, down from ~60%).
- The depth of parchment during skin drying should not exceed around 5 cm. A practical way to verify this is to place a finger vertically in the parchment at the middle of the table to see if the parchment reaches above the halfway mark of one's finger (roughly 5 cm).
- Any parchment sorted out at the skin drying tables becomes grade C and processed as such.

**Skin drying**

**Defects to look for:**


**Beans that should not be sorted out are:**

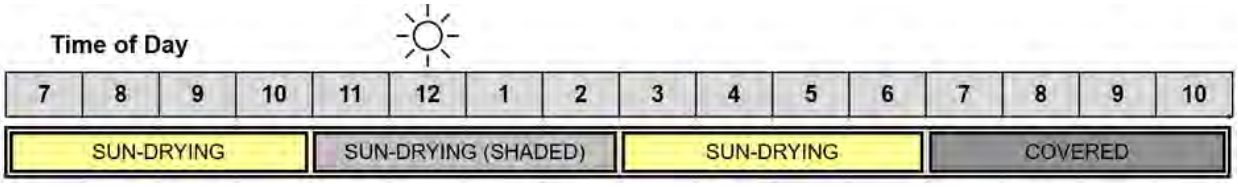

[30]

**An example of sorted out parchment defects**

## Guidelines for Final Coffee Drying:

- Ensure the staff are well trained, motivated, and compensated for their work.
- Ensure the drying tables are straight and not sagging (the wire in the middle hangs lower), as this varies the depth of parchment on tables and prevents uniform drying. Mesh wire should be fixed as for the drying surface to be flat, either by straightening it out and re-fixing it to the sides of the table or strengthening the table frame by additional lateral beams.
- Clean the drying tables; remove any parchment from previous drying to avoid contamination.
- Do not use torn nylex and shade nets to avoid rewetting and spillage respectively.
- Avoid foreign smells; keep high standards of hygiene. The drying area should be free from domestic animals, other crops, foreign smells, fumes or smoke. Odors can affect bean quality.
- Ensure workers wash their hands before turning parchment to prevent contamination.
- Dry different coffee batches and grades on different tables and label for traceability, do not mix coffee batches before they are fully dried.
- The depth of parchment should not exceed 5-7 cm on final drying tables. A practical way to verify this is to place a finger vertically in the parchment at the middle of the table to see if the parchment reaches above the middle of the finger (5-7 cm).
- During the hottest part of the day, it is advised to pile the coffee and cover it to keep from reaching excessively high bean temperatures. This is why consistent readings with the infrared thermometer is important. Parchment coffee on drying tables should be turned constantly, ideally every 2-3 hours, and at least four times daily for fast and uniform drying. During the first days of drying this is even more crucial and should be done more frequently to ensure even drying. As the parchment gets close to being fully dried, pile the parchment a bit higher to prevent the risk of scorching (overheating) as bean temperatures and ambient temperatures are closer together towards the end of drying.
- Uncover the nylex and the shade net early in the morning by 7 am (as soon as the first worker arrives and the sun is up) to allow aeration and make full use of early sunshine hours.
- Let the parchment coffee cool before covering the coffee at night (as parchment only reaches its highest bean temperature towards the end of the afternoon) and only cover coffee after dusk (7pm). In case daily workers have already left, wet mill staff working in the evening should be made responsible for this. This serves two purposes: limits the exposure of the coffee to moisture that accumulates in the air at night and allows for some homogenizing of moisture levels within the coffee mass.

**Figure 27: Parchment on final drying beds sun drying schedule**




- Wet mills can choose to sort out cracked parchment beans on the tables as drying will not be consistent for those beans. However, cracked parchment present a business loss to the wet mill so it is better to focus on frequent turning and covering by shade net during the peak of the day to prevent too much cracking.
- If dried too quickly, the moisture will not be uniformly released from the center of the bean and will negatively affect the coffee color and quality.

[30] Note that elephant bean here means a large bean, whereas in other regions they call a hard shell before its splits an elephant bean or ear.

- Parchment should be covered during rains and at night to avoid rewetting which affects quality. Next to direct rain, morning dew could also rewet beans, so use shade net cover during the night under the nylex as to avoid direct contact between the nylex and parchment.
- Do not under dry or over dry coffee. When getting close to the moisture target, monitor every hour, using properly calibrated moisture meters. Test meters regularly and before each season. If in doubt about the exact percentage, take the coffee off a little earlier rather than letting it over-dry, especially if the coffee will be held in conditioning bins.
- Higher heat can be better withstood early in the drying process, as parchment dries out high temperatures becomes a bigger risk. To save on space and to prevent the risk of dry parchment scorching in the sun, stack parchment a bit higher towards the end of drying.

## Under-Drying and Over-Drying Coffee:

- Under-drying causes molds to develop, lowering the coffee quality and is a health risk.
- Over-drying costs money: not only is weight and money lost, but the accompanying loss of color lowers cup quality. When moisture drops below 10%, aroma, acidity, and freshness begin to fade away. In addition, moisture levels below 10% increases the breakage of beans at hulling.

### What to do when you run out of drying space during the peak of the season?

When there is a lack of available space during the peak season, the following actions can be undertaken to mitigate the negative effect this will have on quality:

- Reduce intake of daily cherry volumes to only buy what the mill has capacity to process
- Take lower grade coffees off the drying beds (these can be temporarily stored (ensure aeration) and taken out on the drying beds towards the end of the season when drying space becomes available)
- Increase the height of parchment that is driest (as coffee dries the height of parchment can be slowly increased).
- If needed before peak harvest, build additional drying tables (do not build after the peak as it will be too late). Or in case there is a neighboring station with excess drying capacity (unlikely during the peak season) negotiate renting some of the space and move over parchment (note that this involves additional costs).

## At the end of the season:

- Repair the drying tables – replace any worn out timber, coffee netting, and straighten all sagging tables. Treat the bottom of the table poles with used motor oil against termites and gradually replace the wooden tables with metal ones. Alternatively, pull up all drying tables and store them in a dry place to avoid wear and termite damage.
- Replace any worn out nylex and shade nets.
- Fold the nylex and shade nets and keep in a good place free from any damage from vermin.

# 6. Bagging and Storage

## Wet Mill Processing Stages

Cherry receipt

Pulping

Mucilage removal

Washing

Drying

Storage

This is the final step of wet mill processing.

The purpose of storage is to safely keep and preserve the quality of the parchment until it is moved to the dry mill. Fully dry parchment is packed in bags and either moved to the parchment store or bulked in conditioning bins.

If using conditioning bins, the coffee can be moved when the moisture content is about 12% as drying may continue while in the bins compared to storage in bags [31].

The conditioning bins should be labelled and the coffee store well demarcated for traceability. The parchment should not stay in the store for too long before milling.

[31]Note that this does not apply in high humidity settings when coffee does not continue to dry but could in fact increase its moisture content during storage. Monitoring of the relative humidity of the air is advised.

**Figure 28: Parchment store (left) and conditioning bins (right)**

## Guidelines for parchment storage:

- Ensure info from labels on drying tables with date of pulping and grade are transferred to the bag (e.g., on the bag, write the wet mill name, day of pulping, grade, and weight).
- Observe high standards of hygiene while handling coffee.
- Store coffee in clean bags. If reusing bags, check there is no parchment left from the previous season, the bags are clean and free of any foreign smell, and are not torn.
- Use the coffee storage exclusively for coffee. Do not keep fertilizers, fuels, oils, or other crops in the coffee storage. This avoids contamination and loss of quality.
- The relative humidity of the warehouse should be between 50-60% and the temperature below 25C. However, humidity is more significant to quality than temperature. One way to minimize the impact of humidity and temperature is to ensure proper airflow through the warehouse.
- The coffee storage should be well cleaned, ventilated, leak proof, and vermin free. Do not store fertilizer, fuels, oils, etc in the same warehouse as coffee.
- Stack the coffee bags on raised pallets, 15 cm from the floor and at least 30 cm from the walls and roof. The first batch to get into the store should be the first out to the dry mill; stack the bags to allow for this FIFO (first in first out) plan while loading the delivery truck.
- Keep clear records of parchment bags and weights moving into storage, do not mix different grades in storage.
- The coffee storage must be under lock at all times.
- Coffee should be weighed and recorded before getting in and out of the store to monitor moisture loss and identify potential theft.
- If doing bulk storage in conditioning bins, clean the bins and remove any parchment from the previous season before putting in new coffee. Ensure the roof is leak proof to avoid rewetting.

## Transport to the Dry Mill

When transporting coffee to the dry mill, maintain high standards to preserve the quality of the beans.

**Figure 29: Closed truck (left) and loading of coffee bags for transport to dry mill (right)**



### Guidelines for transportation to the dry mill

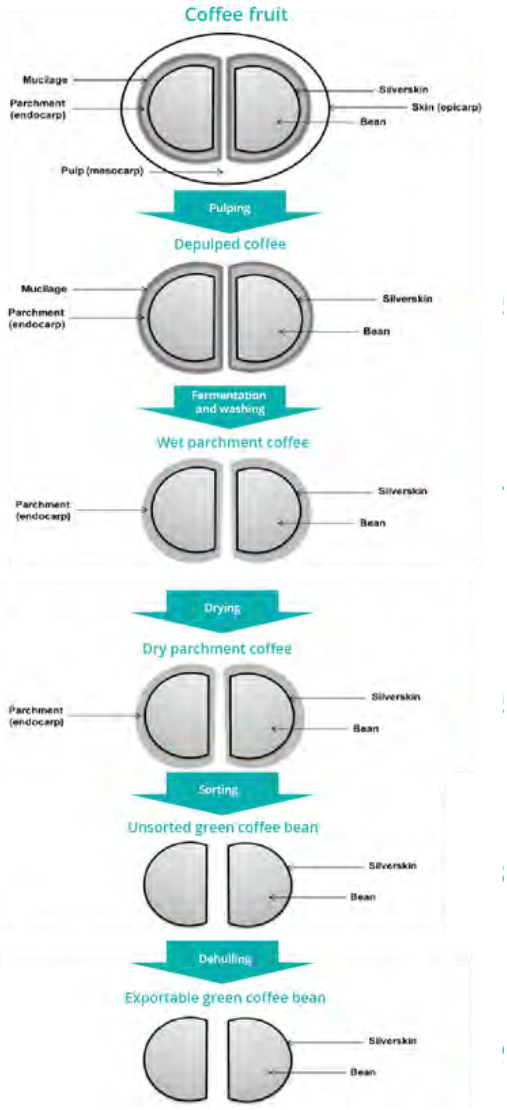
- Use a closed truck, exclusively for coffee. Do not mix coffee with any other commodities or items in the same truck.
- he truck must be leak proof to prevent rewetting of coffee while on transit.
- Clean the truck well; the floor and walls must be dry before coffee bags are loaded and the truck should not have any foreign smell.
- Transport coffee during the day in dry weather, preferably on a sunny day.
- Prepare all paperwork and documentation ahead of time and arrange for armed security.
- Keep proper records of coffee bags loaded on the truck for traceability. Truck loading should be on a “first in first out” basis; the first parchment to get into the store are the first to be loaded. Do not mix coffee grades while loading the truck.

# Wet Mill Economics

To manage a wet mill well, the manager needs to process cost efficiently. The three key aspects to monitor processing costs are 1) the wet mill turnout ratios, 2) operational costs and 3) capacity utilization rate:

Firstly, turnout ratios show you how effective you are in turning cherry into parchment and parchment into green coffee. These ratios can be used to evaluate quality of raw material, detect processing issues which could impact quality, potential theft as well as ensure cost effectiveness. As rule of thumb, a wet mill needs 5 kg of cherry to produce 1 kg of parchment, 6 kg of cherry to produce 1 kg of green coffee, and 7 kg of cherry to produce 1 kg of export grade green coffee.
The more precise and detailed breakdown of turnout ratios can be found in figure below.

**Figure 30: Coffee fruit to green conversion**

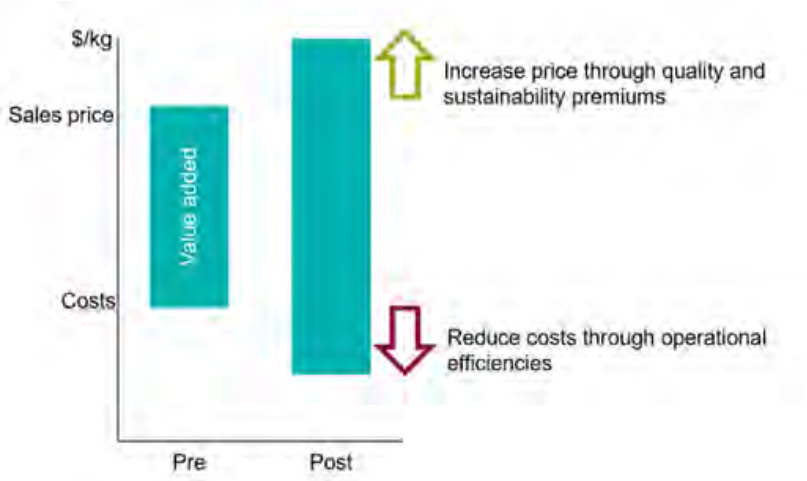



| | % of previous form | Ratio to Cherry | Example |
|---|---|---|---|
| | | 1:1 | 100 kg |
| | 55% | 1.8 : 1 | 55 kg |
| | 71% | 26.6 : 1 | 38 kg |
| | 51% | 5 : 1 | 20 kg |
| | 80% | 6.3 : 1 | 16 kg |
| | 90% | 6.9: 1 | 14 kg |

[32] Modified from an original image from the following article: Rita C.Alves, FranciscaRodrigues, MariaAntónia Nunes, Ana F.Vinha, M. Beatriz, P.P.Oliveira (2017), Chapter 1 - State of the art in coffee processing by-products in Handbook of Coffee Processing By-Products. Published by the Academic Press. Found on 20 June 2021 on https://www.sciencedirect.com/science/article/pii/B9780128112908000013

Apart from above turnout ratios, it is important to monitor the grade categories the parchment consists of. Grade A parchment is derived from both the main output and re-passed output which stays behind as the densest coffee in the grading channel. For stations where there is no grading channel, it consists only of the main output of the pulper. Grade B consists of both the main and re-passed output which is graded in grading channel as of lighter than Grade A but the lightest or floating. For stations where there is no grading it only consists of re-passed coffee or cherry pulped outside of the main pulping hours. Grade C consists of all floating and lightest pulped parchment (or floated as cherry and was separately pulped) plus all sorted out parchment at skin drying table. **As a rule of thumb, wet mills are expected to have a 90% of Grade A output and <2% of Grade C.** However, at the beginning and at the end of the season the Grade A output % is expected to be lower (through lot separation the coffee produced during the tail ends of the season can be cupped to determine whether to sell them separately). If the Grade A output is below 90% during the main harvest period, a wet mill should implement stricter cherry reception quality control.

**Figure 31: Value addition through cost control and price premiums**




Secondly, wet mill operational costs should be monitored to ensure your processing cost are below the value you add to the product as determined by selling price minus cost (see figure 34). If operational costs are higher than value added, the wet mill should consider stopping its operations unless greater cost control is exercised. It is important to focus on reducing inefficiencies whilst not compromising of quality. For example, it is good to reduce the number daily workers when volumes are low but not a good idea when volumes are high as it would negatively impact the number of times the parchment is turned in a day (affecting quality and hence sales price).

**Figure 32: Rough breakdown of wet mill operational costs in East Africa**

| | As a % of total |
|---|---|
| Cherry Purchase | 80-85% |
| Cherry Transport and Commision | 3-5% |
| Labor (Full-Time) | 2-3% |
| Labor (Casual) | 3-5% |
| Repairs and Maintenance in-season | 1-2% |
| Fuels and Oils | <1% |
| Other Expenses | 4-6% |

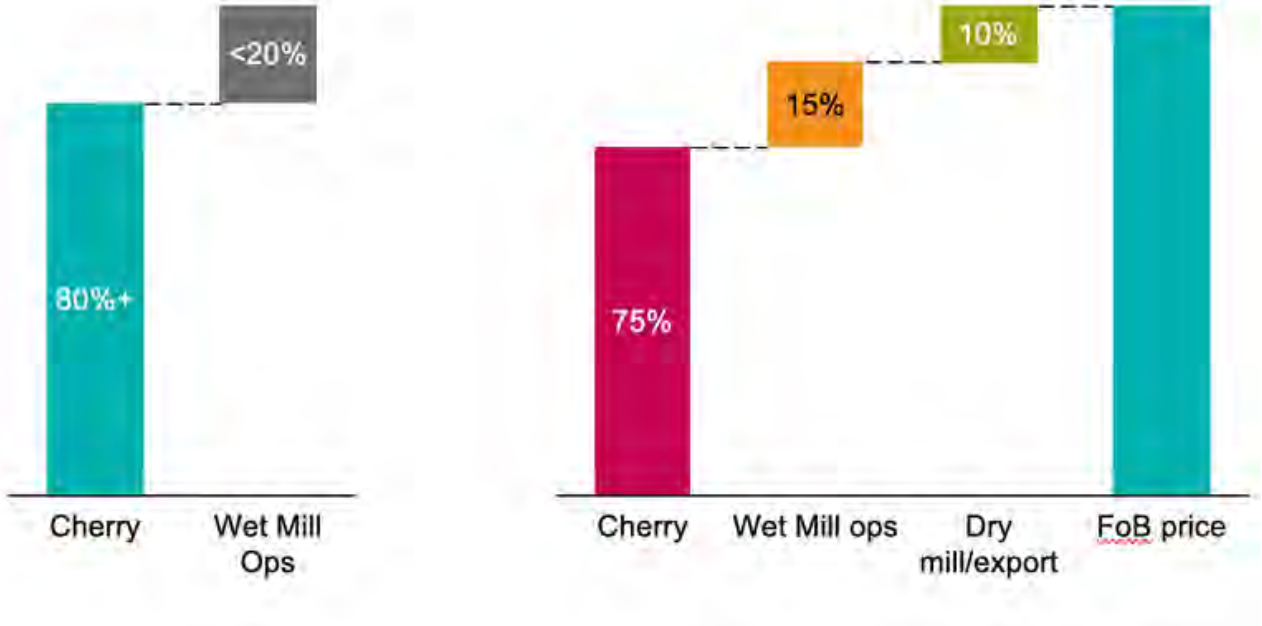
[33] TechnoServe historical wet mill expenses analysis in East Africa

To monitor cost efficiency, the wet mill is advised to track its expenses, break them down in cost categories and perform a weekly audit. See an example of cost categories below. To allow for accurate monitoring avoid getting too many expenses getting grouped as 'other' and create a new cost category if needed.

While cherry cost is the largest wet mill expense, prices are usually determined by the open market so not easily controlled. In actual sense, paying more than the neighboring wet mill or local market can be a good strategy if the quality premium received as a result is higher than the additional costs incurred. If paying above market prices for cherry, it is advisable to link this to cherry quality (selectively harvested deep red ripe cherries fetch a higher price) as to pass on the market (which rewards quality) feedback directly to the farmer and align incentives across the supply chain. As cherry price is largely determined by market forces, focus on the operational expenses incurred at the wet mill the manager has control over. **As a rule of thumb, wet mills should keep operational expenses below 20% of working capital used in-season.** In other words, ensure at least 80% of working capital is spend on cherry purchases. A tool to calculate daily laborers required on the wet mill can be accessed here. To accurately track costs and turnout ratios, use a bookkeeping system and preferably digitize wet mill records to allow for easy analysis. A bookkeeping system includes cherry delivery records, parchment records, dry milling report, cupping records, lot traceability sheet, expense book, asset register, annual budget, profit and loss statement, loan documentation, sales documentation. An example of a traceability sheet can be found **here**.

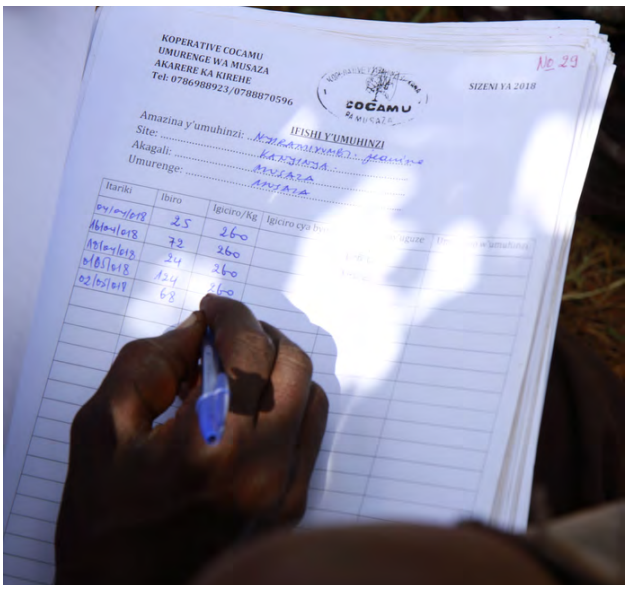
While not part of the scope of this manual, some buyers are interested in farmer share of FOB or export price. A normal farmer share of the FOB or export price in East Africa is 75% (in other parts of the world this % tends to be higher). The farmer share consists of both price paid for cherry (converted to per kg of green) as well as any end/post season profit share/bonus (again expressed per kg of green) paid out.

**Figure 33: On the left a break down between cherry and operational expenses at wet mill and on the right a breakdown of the export (FoB) price of coffee**



Thirdly, wet mill capacity and volume flow needs to be monitored to optimize the utilization of existing wet mill capacity. To calculate wet mill capacity, see cherry receipt section on p.14 Some tips to optimize wet mill capacity utilization:

- Avoid buying during the tail ends of the season; volumes tend to be lower, quality and turnout ratios tends to be lower, and as a result per unit costs are higher than during the peak of the season.
- Avoid pausing cherry purchases during the season. Ideally, wet mills should to continually purchase throughout the season which requires collection sites (if used) to always be open during agreed upon operating hours and cash on site (if using spot payments) not to miss out on any cherry deliveries. If buying cherries through spot payments, working capital monitoring becomes mission critical as a week having to halt cherry purchases during the peak of the season can be detrimental for a season's profitability. Next to working capital, drying table capacity needs to be constantly monitored as to inform daily cherry targets. Also ensure all wet mill equipment is in good condition to avoid in-season breakdown such as pulping machine failure or the sagging of drying tables. Always give drying space priority to high grade coffee. To lengthen the processing season, try to buy from different altitudes if possible within the action radius of your wet mill. Lower altitude grown coffees tends to ripen earlier, and high altitude grown coffee tends to ripne later in the season. If the taste profile of the sourcing areas significantly differ, keep the batches separate using lot traceability discussed on p.49.
- Be aware of what bottleneck determines wet mill capacity and focus on managing the bottleneck resource capacity utilization (either pulper, tanks, or beds). If the bottleneck is machine capacity, organize cherry delivery to start pulping earlier. If the bottleneck is the number of fermentation tanks, try dry fermentation and covering the tanks with sheet at night to speed up the fermentation process. If the bottleneck is drying beds (which is true for many wet mills) consider adding beds and straighten the mesh wire and intermediate beams to increase holding capacity, ensure the overnight nylex cover is opened as soon as the sun is out, remove low grades from tables during the peak of the season (can be put back when space available) and possibly increase the height of the almost dried parchment.




# Sustainability Concerns

So far, this guide has covered quality as a means to increase value creation at the wet mill while controlling processing costs. Another way to increase value is to adopt internationally accepted sustainability standards. These are good business and farming practices which promote sustainable coffee production, throughout the chain. Not only is compliance with these standards a potential path to obtain price premiums from buyers, it is also good business as it ensures farmers, workers, and the environment are not negatively impacted, hence making it possible to sustain the business long-term. An element of sustainability is economic transparency which has already been discussed under the cherry delivery section (issuing farmer receipt) and the previous section on wet mill economics (traceability and farmer share of export price). The two remaining basic elements to be discussed are social and environmental responsibility.

## Social Responsibility

Social Responsibility – encourages fair and ethical employment practices, includes standards on wages, benefits, no discrimination and access to management. If you workers are treated fairly and with respect they are more likely to remain loyal, hardworking and follow quality processing requirements.

Examples include:

- Child labor - All hired workers must be above the minimum working age as per the national law.
- Forced Labor - Workers will offer their labor voluntarily.
- Minimum wage – All workers shall be paid the minimum nationally mandated wage.
- Discrimination/Equal Treatment: All workers should be treated equally.
- Other good practices include not working more than the nationally mandated number of hours, paying for overtime, paying legally mandated benefits, having a labor and a gender policy in place, written employment contracts for permanent staff, and attendance records for daily workers.

**Figure 34 : Example of social responsibility practices are not allowing child labour (left) and building a female and male toilet on site for daily labourers (right)**

- Provide a fully equipped first aid kit on site and develop a simple and efficient emergency procedure for any unforeseen accidents and fire break out.
- Develop an occupational health and safety policy on how the wet mill promotes a safe working environment, including standards on workplace safety, emergency planning, and health-related issues such as sanitary facilities and access to potable drinking water. Workers should be trained on the policy and staff doing dangerous work should be provided with personal protective equipment (e.g., ear muffs for the machine operator). Following the policy will reduce the chance of accidents, giving workers a safer working environment.

**Figure 35 : Example of a vetiver wetland to manage waste water in an environmentally sustainable manner (pulp first needs to be separated from the waste water and composted)**

**Figure 36 : Vetiver rows planted in a "V" towards the evaporation tank at the end of the wetland. Note: Grass is planted in all areas around the vetiver wetland, leaving no bare soil exposed.**

**Figure 37 : Example of pulp composting with organic matter cover and lime added**

**Figure 38 : Rows of pulp compost (2m in between to allow for turning)**

## Environmental Responsibility

Environmental Responsibility – promotes management of all resources and landscapes in coffee production and processing in a manner that protects the local environment, producers, workers and the community, includes standards on conservation of wildlife and forests, waste management – water, pulp, and husks - and efficient use of resources such as water, energy, and soils. The community will benefit from natural resources such as less pollution from waste products (pulp, water, and husks) and forest products for generations to come.

Examples include:

- Waste water management - Waste water shall be separated from pulp and managed as follows: If untreated, waste water should be contained in ponds at least 30 m from any water body. If treated, water can only be released into water bodies after testing and compliance with national and/or international standards. A skin tower or pulp hopper can be constructed to separate pulp and water and a vetiver wetland installed to absorb and filter the water.
- Coffee Pulp Management: Pulp shall be converted into a productive by-product, for instance, compost for use as organic fertilizer by producers. Composting correctly involves piling up the pulp in small rows of pulp banks (turned monthly) where it gains exposure to air to facilitate the decomposition process [34]. Optionally, a wet mill can add effective microorganisms (EM) or lime to quicken pulp decomposition and remove any bad smell from rotting pulp.
- Reduce use of water: There shall be demonstrated efforts to use water efficiently; for example, the use of eco-pulpers, water re-circulation, or other techniques
- Other good practices include tracking of water (through water meters) and energy consumption, water body protection, wildlife protection, general waste management, and parchment husk recycling.
- Environmental Conservation: Cutting of primary forest or destruction of natural resources is not permitted and cannot have occurred in the last 5 years.
- Probitited Pesticides – Products included on the WHO Pesticides list or those that are not legally registered for use in coffee shall not be used.
- Storage of Pesticides: Pesticides shall be stored in a manner that minimizes the risk to human health and the environment (e.g., safe storage, proper signage)
- Adoption of sustainable agricultural practices on supplying coffee farms such as pruning and rejuvenation, Integrated Pest and Disease Management, shade trees, erosion control, composting, mulching, and cover crops.

Note that the list above only provides some examples of the type of issues sustainability standards deal with. For a comprehensive overview of these standards contact TechnoServe or one of the certifying bodies which each have their own focus such as FairTrade, Rainforest Alliance, USDA Organic, 4C, C.A.F.E. practices, Nespresso AAA TASQ.

We hope you enjoyed this quality processing manual aimed at wet mill owners and managers in East Africa. In the annex several checklists can be found to monitor processing best practices implementation at your wet mill.

For any comments or questions on this manual, kindly contact coffee@tns.org

[34] Putting pulp into a pit or large pile will prevent the access of air to the composting bacteria. Well composted cherry pulp will look like fertile dirt, whereas poorly composted cherry waste will look like slimy mud.

# ANNEX: Checklists

**Checklists which can be used at the wet mill site:**

1. Daily Coffee Processing Quality Index
2. Weekly Coffee Processing Quality Index
3. Pre-season checklist
4. Cherry reception checklist
5. Pulping checklist
6. Fermentation checklist
7. Washing checklist
8. Drying checklist
9. Storage, bagging and transport checklist
10. End of season checklist

These checklists can be printed and multiple copies of each hang in a plastic cover at the respective locations around the wet mill site for the responsible person to fill out on a regular basis. For the daily and weekly CPQI audit a mobile application is available for wet mills, if you would like access to the app kindly contact the nearest TechnoServe representative or email coffee@tns.org.

# DAILY COFFEE PROCESSING QUALITY INDEX - CPQI

Wet mill Name:
Date: Time of Day:
Evaluator:

NB: This check is best performed during the afternoon when there is both drying and pulping activities going on

| Statement | Score | Comments |
|---|---|---|
| **Cherry reception** | | |
| At the cherry collection sites only red ripe cherry is accepted and mixed cherries are rejected<br>*Check in cherry bags and/or hopper that from the 50 randomly selected cherries at least 90% (40 cherries) are within the ripeness target range* | | |
| At the wet mill, cherry is (re)sorted by color (hand picking) or by density | | |
| **Pulping** | | |
| Cherry is pulped within 8 hours of picking<br>*Check if wet mill starts pulping during the afternoon for early harvested cherries, that cherries are delivered before dark to allow for quality audits/re-sorting during daylight, and that pulping finishes before midnight* | | |
| Water source and all water used is visibly clean<br>*Check source/ water tank* | | |
| Pulping machine is working well, clean (cleaned daily) and fermentation tanks are clean with no old beans left (cleaned after each use)<br>*Check the pulleys and all belts for slackness, check the size and density sorter is operating well and nothing is clogging the machine, check tanks for cleaness* | | |
| Coffee beans leaving the machine are not cracked and pulp is well separated from parchment (i.e. calibration correct)<br>*Check output (randomly inspect 50 beans) to ensure <5% white beans or cracked parchment (no more than 2 beans), <10% unpulped cherry (no more than 4 beans) and <10% pulp pieces (no more than 4 skins)* | | |
| **Mucilage removal** | | |
| For full fermentation (otherwise skip): Parchment coffee of different grades put in seperate tanks and processed seperately. Stage of fermentation process in each tank is monitored to determine the correct washing point (eg. twice a day during 1st day and every 2-3 hours during the 2nd day of fermentation)<br>*Check record or ask staff when the last check was performed and check stage of fermentation through rubbing beans in hands to check gritty sound and pebble feel and wash some parchment to see if mucilage washes away easily* | | |
| For mechanical mucilage removal (otherwise skip): while in operation the outside of the demucilager sieves are brushed to prevent clogging. Demucilager is cleaned after its use to ensure no beans or mucilage is left behind<br>*Check demucilager* | | |
| **Washing** | | |
| Parchment coffee are washed until all mucilage is removed and beans are properly graded if using a grading channel. Grading channels are kept clean<br>*Check if any mucilage left and check grading consistency between different days. Check channels for cleaniness* | | |
| **Drying** | | |
| Parchment coffee on skin drying tables is sorted to remove defects after washing when still wet and turned constantly<br>*Check defect sorting of wet parchment coffee (high grade), defective parchment moved to low grade and all parchment coffee turned constantly* | | |
| Parchment coffee on final drying tables less than 5cm deep and turned every 2 hours for uniform drying<br>*Place index finger into drying parchment coffee and check that depth is not higher than second ligament of the finger . Check with infrared thermometer that bean temperature does not exceed 35C or feel by hand to check there is not a large temperature difference between parchment at bottom and top of the heap.* | | |
| Parchment coffee covered with shade net during heat of day between 11am and 2pm (if sunny)<br>*Check that shade net is being used to cover parchment coffee between 11am and 2pm* | | |
| Shade netting and/or plastic sheeting is put on at night and removed early in the morning before 8:30am (as soon as the first worker arrives) | | |
| Moisture is checked daily when almost dry, and dried to 10-12% moisture content before moving to store<br>*Measure moisture of oldest parchment on tables or newest parchment in coffee store and/or check records* | | |
| **Total score** | | |

*CPQI scoring: 1 = statement is true 0 = statement is partly true -1 = statement is false*

# WEEKLY COFFEE PROCESSING QUALITY INDEX - CPQI

Wet mill Name:
Date: Time of Day:
Evaluator:

Nb: This check is best performed during the afternoon when there is both drying and pulping activities going on

| Statement | Score | Comments |
|---|---|---|
| **Cherry reception** | | |
| Weighing scale starts at zero before weighing each farmer's sorted coffee and delivery receipt issued to farmer<br>*Check if scale starts at zero and check if the name of farmer, date, volume and price is filled out on receipt* | | |
| **Drying** | | |
| Mesh wire on the drying tables is sufficiently flat to ensure consistent depth of parchment across the table (no sagging)<br>*Check drying tables* | | |
| Dry parchment is properly covered with plastic sheet during rain (checked if not torn anywhere) and uncovered after<br>*Check during rain (otherwise leave open)* | | |
| Parchment on final drying tables are seperated and labelled by lot indicating the pulping date and grade<br>*Check drying tables* | | |
| **Storage** | | |
| Dry parchment stored in a dry, clean, and rodent/ insect free place in clean bags, free from any smell and away from the floor and walls. Store is well ventilated and bags stacked on pallets or raised 15cm on wooden poles.<br>*Check store for dryness and cleaniness (no leaks), monitor inside temperature (<30C) and airflow. Check distance from wall (>30cm) distance from floor (>15cm)* | | |
| Store register is kept and separate lots are labeled by grade and date<br>*Check register and check if label or writing on bag (or bin) includes pulping date and grade* | | |
| **Social and environmental standards** | | |
| On wet mill site no waste water is emitted to natural streams or ground. The channels transporting the water or evaporation ponds or wetland do not overflow.<br>*Check for signs of recent overflow around channels and ponds* | | |
| There is no visible sign of unneccesary water spillage<br>*Check for any unnecesary spillage (eg. running taps/broken pipes); specifically check water tank, pulping, fermentation and grading channel areas.* | | |
| Coffee pulp separated from wastewater and stored seperately<br>*Check if there is a system to separate pulp from wastewaste in place (eg. pulphopper or filter in channel)* | | |
| The moving parts of the pulper are shielded off by guards; the evaporation ponds are fenced off; no sharp materials are lying around; and workers are not exposed to any danger<br>*Check machine area* | | |
| Workers on site are working under good working conditions meaning they have access to potable water as well as sanitary and hand-washing facilities<br>*Ask workers about working conditions and check whether toilet, handwashing and drinking water is available* | | |
| There is not a single underaged worker (<15 yrs) on site<br>*Ask youngest looking worker their age* | | |
| **Bookkeeping and Financial Management** | | |
| All wet mill income and expenses are recorded in designated books (paper or digital) and receipts issued for each (preferably a carbon copy kept for filing).<br>*Check whether a proper accounting system is in place and being used* | | |
| Cashflow is managed effectively so that the wetmill does not need to stop cherry purchases and any on credit delivered cherries are paid out to farmers within the agreed period. Equally, wet mill workers are paid within the agreed period.<br>*Check whether any collection sites were forced to stopped buying over lack of liquidity and whether cherry purchases on credit and workers wages are paid within agreed upon timeframe* | | |
| **Total score** | | |

*CPQI scoring: 1 = statement is true 0 = statement is partly true -1 = statement is false*

# PRE-SEASON CHECKLIST

Check as appropriate

- [ ] There is a constant, clean source of water
- [ ] The water recirculation system (if applicable) is working and the recirculation pump has been serviced and greased with white grease.
- [ ] Water pumps (if applicable) have been serviced and any associated worn-out tubing are repaired or replaced.
- [ ] The water meter is in place and working (if applicable)
- [ ] Water faucets/taps and drainage valves for syphon tank (if applicable), fermentation tanks, holding tanks, washing channel, pulping machine and hopper have been inspected and replaced if needed
- [ ] The wet mill infrastructure is in a good state of repair and clean: floatation tank, cherry reception hopper, fermentation tanks, grading channels, pulp hopper, holding tanks, water tank, pulp and waste water channels, gravity water channels
- [ ] Check machinery setting toolkit for available tools and replenish with needed tools.
- [ ] Check and replace any worn or broken machine parts
- [ ] The Generator is serviced and ready for use
- [ ] General wet mill area is clean (no old pulp or trash) and grass is cut between and underneath the drying tables
- [ ] Drying tables are sufficient and in good working condition with the mesh wire straightened and tables reinforced where needed
- [ ] Storage area clean and free of any garbage, chemicals, odors, moisture, dust etc.
- [ ] Weighing scale is calibrated by a licensed agency
- [ ] Pulping machine calibrated and oiled

- [ ] Covering materials such as nylex and shade nets are available and in a good state of repair (checked for holes)
- [ ] All bookkeeping books needed for the season are sufficiently in stock
- [ ] Full time staff is formally contracted and all wage arrears have been settled
- [ ] Daily workers identified and attendance timesheets are in place
- [ ] Collection sites are identified, authorized and agents have been contracted
- [ ] Staff and cherry collectors received a (refresher) training
- [ ] Collection sites access roads surveyed and appropriate transport chosen for transport from site to wet mill
- [ ] Collection site purchasing materials are in place for all sites (eg. shade, weighing scale, tarpaulin, recording books/receipts)
- [ ] Season cherry target has been determined and season start date has been set
- [ ] Estimated daily intake targets have been calculated for early, mid and end of season
- [ ] Purchasing dates, locations and opening hours have been communicated to the surrounding communities
- [ ] The anticipated cherry prices (where applicable) and expected cherry quality communicated to farmers in sourcing communities.
- [ ] Working capital financing has been secured
- [ ] Former and/or prospective buyers have been informed about your plans for the upcoming harvest season
- [ ] The vetiver wetland is in place and maintained (if applicable)
- [ ] Lagoon and pulp pit have been inspected, and if needed, cleaned and ready for operations.
- [ ] EMO (effective microorganisms) needs have been calculated and purchased for pulp composting (if applicable)
- [ ] Fuel and oil needs for vehicles, pumps, generators etc. have been calculated and drums of fuel have been prepared for operations for x number of days.

# CHERRY RECEPTION

Check as appropriate

- [ ] Selective picking of only dark red ripe cherries
- [ ] Cherry delivered to wet mill within 6-8 hours of harvesting
- [ ] Cherry bags visibly clean
- [ ] Quality check performed on cherries by collection agent
- [ ] Cherry sorting done
- [ ] Foreign materials removed - stones, twigs, leaves, and other crops
- [ ] Cherry hopper clean, free from any previous harvest cherries
- [ ] Cherry in the hopper within acceptable color range
- [ ] Receipts issued for cherry deliveries

# PULPING

Check as appropriate



## Daily: before pulping

- [ ] Clean water used for pulping

## Daily: during pulping

- [ ] Check parchment coming from the machine unbroken and pulp is well separated from parchment
- [ ] Pulped coffee separated by density and size
- [ ] Pulped coffee of different grades separated and in different fermentation tanks
- [ ] Clean the machine with plenty of water and remove any remaining coffee bean or pulp and sugars from last pulping
- [ ] Pulping water recirculated no more than three times and checked for cleanliness.

## Daily: after pulping

- [ ] Clean the drainage and coffee channels
- [ ] Check the slots are in place before next pulping
- [ ] Check the pulleys and all belts for slackness
- [ ] Check water pipes connected to machine for leaks
- [ ] Check settings of chops before next pulping
- [ ] Pulping machine rinsed before pulping

# PULPING

Check as appropriate



## Weekly

- [ ] Clean machine and machine house thoroughly (sugars stain the machine/machine area) and letting machine house dry
- [ ] Grease all bearing/moving points (including pre-grader) using only white grease
- [ ] Check chops and knives settings
- [ ] Check pre-grading tank for leaks and repairing if needed
- [ ] Check sieves on pre- grader and conveyor channels for breakages or sharp surfaces that could  break beans
- [ ] Check disc movement, speed and direction: Disc should rotate forward at uniform speed. If the disc is loose or wobbling it is wrongly placed.

## During season

- [ ] Pulper calibrated with harvest progression: 1. start of season (tighter calibration due to smaller bean size) 2. start of the middle of season (looser calibration due to larger bean size) 3. start of end of season (tighter calibration due to smaller bean size). In addition, whenever the output is not optimal, the pulper should be calibrated so there is a clear separation between pulp and beans and beans do not break or nipped (appear white on the skin drying table).
- [ ] If operating on diesel or petrol engine, make routine oil and filter change as per manufacturer's recommendations

# FERMENTATION

Check as appropriate

- [ ] Fermentation tanks smooth, repaired and painted/tiled
- [ ] Fermentation tanks marked with parchment grades
- [ ] Fermentation tanks clean prior to parchment reception
- [ ] All water drained off to allow dry fermentation
- [ ] Extra pulp and floaters on parchment 1 and 2 removed
- [ ] Fermentation time monitored – start/stop - 18-36 hours depending on weather.
- [ ] Parchment physically checked regularly to avoid over fermentation.
- [ ] A gritty sound is produced upon rubbing the coffee on your hands
- [ ] Mucilage on parchment surface washes away easily.
- [ ] Fermentation tanks have roof protection against rains and tanks covered with sheet at night to regulate temperature

# WASHING

Check as appropriate

- [ ] Washing channel smooth, repaired and painted/tiled
- [ ] Washing channel clean prior to parchment reception
- [ ] Clean water used to wash coffee
- [ ] Workers use clean hands, feet/gum boots and are well trained
- [ ] Adequate water flow to wash and grade coffee
- [ ] Stopper wood planks used to control floating/flow of beans along channel
- [ ] Washing done upstream in a stirring fashion, rubbing against each other and the floor, moving light beans downstream
- [ ] Squeegees used to wash coffee are not worn out and bruising the beans
- [ ] Parchment surface clean and free of mucilage before drying
- [ ] Washing water visibly clean before parchment removal for drying

# DRYING

Check as appropriate

- [ ] Drying tables flat and mesh wire is straightened
- [ ] Shade nets and nylex in good condition (not torn)
- [ ] Coffee at skin drying spread thin (+/-5cm), dry within 8 hours from washing
- [ ] Coffee on skin drying tables hand-picked for defects directly after washing so parchment still wet
- [ ] Coffee when moved to drying tables are separated by grades and drying stage
- [ ] Coffee labeled on drying tables
- [ ] Coffee on drying tables turned continuously, each 1-2 hours
- [ ] Coffee depth on tables not more than 5-7cm or 3 inches
- [ ] Bean temperature is monitoring (by infrared meter or feeling by hands) not to exceed 35 degrees Celsius
- [ ] Coffee partially covered with shade netting during peak overhead sun hours
- [ ] Coffee covered overnight and during rains
- [ ] Moisture readings are taken at the same time daily
- [ ] Coffee is dried to 11-12 % moisture content before movement to store

# BAGGING, STORAGE, AND TRANSPORTATION

Check as appropriate

- [ ] Properly dried coffee is moved into store
- [ ] Coffee stored in clean bags
- [ ] If reusing the bags, previous parchment removed from the bags
- [ ] Coffee bags in store weighed, sealed and labeled
- [ ] Store is clean, pest and rodent free
- [ ] Store is leak proof
- [ ] Store is well ventilated
- [ ] Store used exclusively for coffee (no agrochemicals, fuels, other crops)
- [ ] Coffee stacked on wooded pallets
- [ ] Pallets raised 15 cm from the floor and 30 cm from the walls and roof
- [ ] Coffee in store rotated on first in- first out basis
- [ ] Coffee in store separated by lots and grades (label or bag writing must include day of pulping and grade)
- [ ] Transportation to dry mill during the day
- [ ] Truck is clean, closed and leak proof
- [ ] Truck in good condition – new tires, engine function, experienced driver

# END OF SEASON CHECKLIST

Check as appropriate

- [ ] Clean the water tank, cherry hopper, fermentation tanks, washing channel, holding tanks, machine rooms, cherry reception and other facilities as needed
- [ ] Fix all water pipe leaks and shut off all valves
- [ ] Pulper serviced and/or repaired. This includes washing, and painting of all metallic parts to avoid rust and greasing all moving parts. After service the pulper should be locked in a safe location and covered with a sheet
- [ ] If using a screen and/or drum pulper ensure screen and drum are thoroughly cleaned with a hard brush so no organic material remains stuck anywhere. Then apply food grade oil (e.g., coconut oil) with a soft cloth on all metal surfaces including chops and knives to prevent rust
- [ ] Repair the machine hopper if slots are worn out
- [ ] Check the surfaces of all the discs, if smooth, then remove and spray all worn-out discs to be ready for the following season. The surface of the discs should be rough to pulp efficiently. There are special workshops that spray the discs
- [ ] Check that the discs are correctly assembled and not on reverse orientation; each disc has an arrow which points forward if assembled correctly
- [ ] Checking all bearings and replace worn out bearings
- [ ] Replace any worn out knives and chops
- [ ] Replace any worn out belts and chains
- [ ] Repair or replace any broken parts
- [ ] If using a diesel or petrol engine to drive the pulping machine, conduct routine maintenance, replace oil, and replace filters to be ready for the next season

- [ ] Check pulleys and replace worn out pulley links
- [ ] Remove fuel and oil from engine/generator and clean
- [ ] The motor (taken off pulper) is stored in a locked place and covered with a waterproof tarp to ensure that it does not rust when it is not being used
- [ ] Repair fermentation tanks and washing channel, seal any cracks and damages sustained throughout the season. If the surface of the tanks is tiled, then replace any worn out or broken tiles. If the tanks and washing channel have concrete surface, repair the cracks and worn-out surfaces and paint using epoxy paint
- [ ] If fermentation tanks are open, erect a roof over the tanks to provide shade and ensure even fermentation by avoiding direct sunlight and protecting against rain entering tanks. If the tanks have a roof already, then check and seal any leaking roofs
- [ ] Drain the water tank and clean the tank by removing all the sediments from the tank base before allowing fresh clean water into the tank
- [ ] Remove all nylex and shade nets from the tables and dry, fold and store them in a place free from any damage from vermin (e.g. rats)
- [ ] Replace any worn out nylex and shade nets
- [ ] Repair the drying tables – replace any worn out timber, coffee netting, and straighten all sagging tables
- [ ] Treat the bottom of the table poles with used motor oil (or special chemical) against termites or upend tables entirely and move to storage. Consider gradually replacing the wooden tables with metal ones
- [ ] Make sure lagoon is treated with EMO for the final time (if applicable)
- [ ] Prepare pulp for composting and distribution to out-growers
- [ ] Inspect store roofs and repair leaks or openings
- [ ] Ensure no left-over fuel is left lying around at the wet mill site (eg. machine house, storage) and all drums have been cleared and cleaned of fuel to avoid hazardous situations
- [ ] Keep stores outer perimeter clean and grass free by 0.5m to control rodents and apply rodenticide if infested.
- [ ] Clean and grease locks, hinges for doors, windows and the gates