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# Harvesting, Post-Harvest Management, and Processing of Coffee

A handbook on coffee processing for MSMEs in West Africa



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European Union



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## Foreword

Coffee is an important agricultural commodity produced in about 80 tropical countries. It is estimated that 125 million people depend on it for their livelihoods in Latin America, Africa, and Asia. Ghana, best known for cocoa production as the world's second-largest producer, is also expanding into the coffee industry. Robusta coffee (*Coffea canephora*) is the type of coffee grown in Ghana, mostly by smallholder farmers in the Ashanti, Bono, Bono East, Ahafo, Central, Eastern, Western, Oti, and Volta regions.

Coffee, as a non-traditional crop in Ghana, has the potential to supplement the country's export earnings through diversification as the country cannot rely solely on earnings from traditional crops such as cocoa. However, coffee production and processing in Ghana remains underdeveloped, thus hindering its great potential for improving the livelihoods of smallholder farmers and agro processors along the value chain.

The importance of reviving Ghana's coffee industry cannot be overstated. Strategies for revitalizing Ghana's coffee industry can only be developed after a thorough examination of the current state of the country's coffee value chain, with a focus on the sustainable intensification of high-quality coffee production. This provides a practical approach to increasing coffee production and processing with a lower environmental impact and improved ecosystem services for future generations.

To obtain first-hand information on the coffee value chain in Ghana, the International Trade Centre (ITC) conducted an enterprise assessment of the coffee value chain actors in Ghana. This assessment identified several challenges, including poor harvesting and drying techniques, use of inappropriate equipment, poor manufacturing practices, low-hygienic environment, poor storage facilities, few innovations on value-added products etc.

This manual was developed based on the findings of the enterprise assessment to provide practical solutions to the challenges identified for coffee farmers and agro processors. The manual is user-friendly and covers postharvest management of coffee, food safety and hygiene, product development and innovations in the coffee value chain. It also draws on information and material from ITC's seminal Coffee Guide, 4<sup>th</sup> Edition.

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Sarah Charles, Communications Consultant for ITC and Co-Author of ITC's *The Coffee Guide, 4th Edition* edited the text and added key references and material from The Coffee Guide.

Camila Gadotti, Graphic Designer Consultant for ITC, did the graphics and lay-out of the publication.

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## Acronyms

Unless otherwise specified, all references to dollars (\$) are to United States dollars, and all references to tons are to metric tons.

ITC	International Trade Centre
UNCTAD	United Nations Conference on Trade and Development
WTO	World Trade Organization
MSME	Micro, small and medium-sized enterprises
ISO	International Standard Organization
FAO	Food and Agriculture Organization
GMP	Good Manufacturing Practices
GHP	Good Hygienic Practices
QMS	Quality Management Systems
FSMS	Food Safety Management System
HACCP	Hazard Analysis and Critical Control Points
FSSC	Food Safety System Certification
BRC	British Retail Consortium
IFS	International Featured Standard
MRLs	Maximum Residual Levels
SOPs	Standard Operating Procedures
PPPs	Plant protection products
CCPs	Critical Control Points
OPRP	Operational Prerequisite Programs

## Chapter 1

# Handling Coffee from Farm to Shelf

Much of coffee's value is acquired at the production stage. Farming and post-harvest processing methods can greatly influence coffee products, in both quality and value. This makes producer, government, and buyer investment in the production process a sensible – if not essential – business move.

Post-harvest processing is an important step in coffee production that heavily influences the quality – and value – of the final product. Multinationals and local cooperatives acknowledge this today and are investing heavily in the dry milling step of the coffee production operation.

Coffee in West Africa is produced almost exclusively by smallholder farmers and the dominant processing method there is the natural (dry) method. Drying and hulling are done in the communities by aggregators, most of whom have hulling machines designed specifically for coffee. However, many still use machines designed for maize or rice to hull coffee, which leads to damaged beans.

Roasting coffee at origin in West Africa is still a nascent practice, and roasting equipment and practices are also often ill-adapted because of a lack of a suitable infrastructure and low access to knowledge and equipment.

This chapter offers a brief overview of practices along the value chain from harvesting to primary packaging, targeting coffee stakeholders in West Africa. It considers current practices and offers recommendations for improved best practices, food safety and processing technology.



Pickers harvest coffee cherries in Leklebi, Ghana. Credit: ACRAM.

## Quality starts with good harvesting

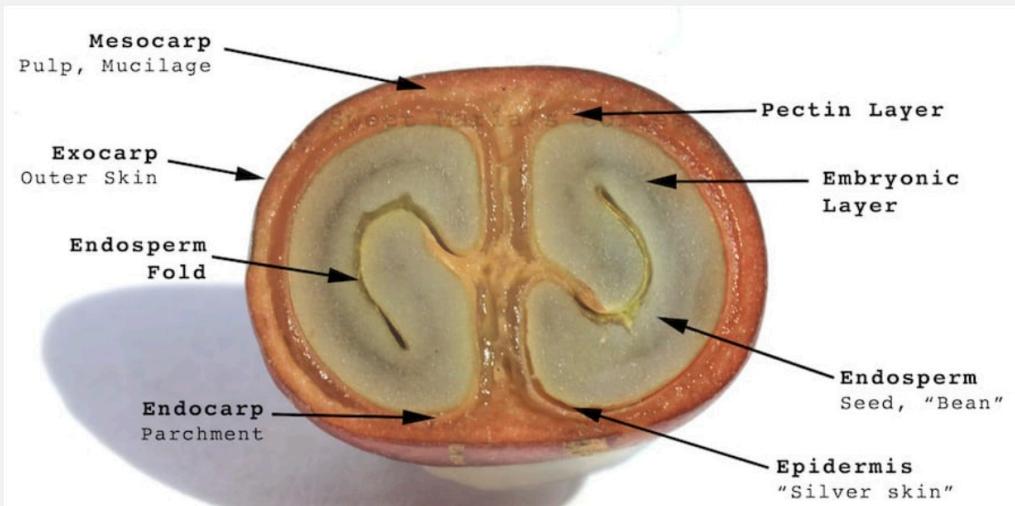
Harvesting among smallholder farmers is manual. Matured, ripe coffee cherries are stripped from the branches onto mats or into baskets. ‘Stripping’ is a quicker way to harvest, but it means that harvested fruits include a combination of over-ripe, ripe and unripe cherries, in addition to debris and plant parts.

A better method is selective picking, where ripe, undamaged coffee cherries are already separated from unsuitable cherries and debris at the harvesting stage. It is a slow and labour-intensive method that smallholder farmers often avoid because of low time and human resources. However, selective picking can save time and effort further down the value chain and produce better quality coffee in the end.

### Box 1 The coffee cherry

Coffee fruit on the trees are known as cherries, consisting of three (3) distinctive parts:

- Exocarp (external skin that is green for unripe and red or yellow when ripe)
- Mesocarp (also known as pulp or mucilage)
- Endosperm (This is the kidney shaped coffee beans which usually comes as pair within the cherry except when one is aborted, allowing the surviving bean to take a rather rounded shape-pea berry). Each bean has a silver skin, and a germ (embryo) inside.



Source: *The Coffee Guide, International Trade Centre (2021)*.

**Table 1** Harvesting coffee: practices to adopt and avoid

Recommended good practices	Bad practices ( Food safety and quality issues)
	

- Harvest only matured and ripe (yellow to red) coffee cherries by selectively handpicking them from the nodes. Handpicking:
- Leaves flower nodes active for new flowers
- Enables hulling of only ripe cherries, meaning less work with little sorting
- Less picking of foreign materials, unripe and over-ripe cherries during drying
- Place a cloth or polythene sheet at the base of the coffee plant during harvesting to ensure all cherries are collected and to maintain farm hygiene standards.
- Unripe and improperly matured cherries should be sorted from the matured ripe cherries prior to subsequent processing.
- Harvest at two (2) weeks intervals

- Stripping coffee cherries off from the branch, including ripe, unripe, matured and improperly matured cherries. Even though the process is faster and less labour intensive, it has many risks:
- The destruction fruit-bearing branches and flower nodes , causing low future yield
- A loss of green cherries that could be harvested a few days later
- More sorting work during drying and after hulling due to the mixing of unripe and over-ripe cherries

The cup quality of coffee is influenced by the quality of harvested coffee cherries, as demonstrated in Table 2. Overripe and unripe cherries introduce undesirable sensory characteristics. It is therefore important that the harvesting and post-harvest techniques all allow for the elimination of overripe and unripe cherrie.

**KYE MESSAGE**

*Even though the selective picking process is more labour-intensive and slower, it is economically more rewarding for farmers in the long run, allowing the production of higher-quality coffee that can reach a higher price. It leads to better coffee cup quality, since only good quality ripe cherries are processed.*

**Table 2** Coffee defects and effect on the cup

Cherry	Green bean defect	Organoleptic impact
Unripe cherries (Green)	Green immature beans Black beans	Harsh (green) taste Hard beverage
Partially dried on the tree before harvest	Black beans	Harsh and woody taste
Naturally fallen cherries picked from the farm floor	Black beans	Harsh and woody taste
Overripe cherries	Black beans	Alcoholic, unpleasant fruity and yeasty taste
Fermented cherries	Fermented cherries	Alcoholic, unpleasant fruity and yeasty taste

## Post-harvest processing basics

Once the harvest is completed, the coffee cherries are transported to a processing facility. The size and mechanization degree of these facilities varies from country to country and from farm to farm. The post-harvest process transforms the unprocessed cherries into green coffee beans ready to be shipped to a roaster.

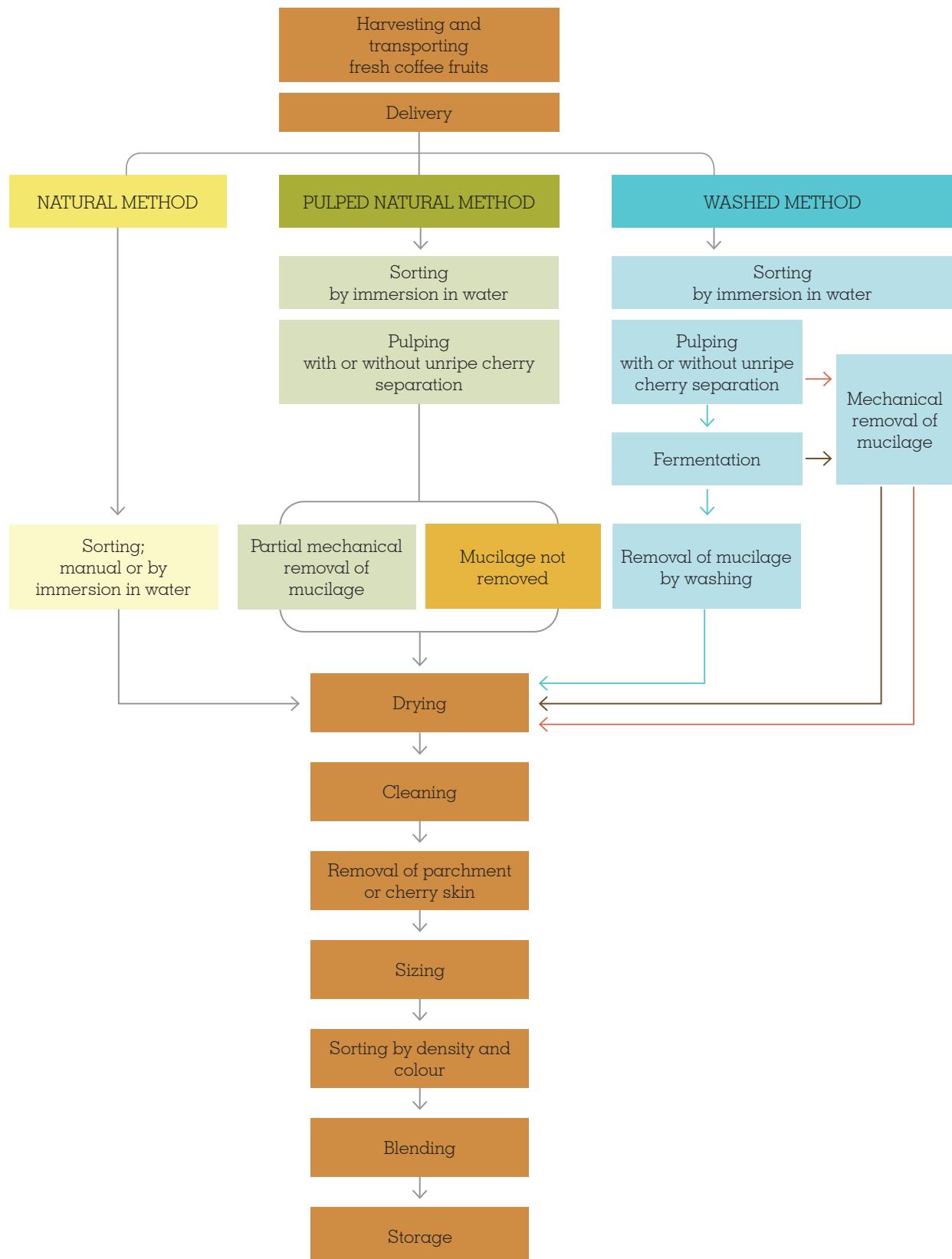
Although this happens before the ‘green bean’ stage, it is nevertheless a sophisticated process that carries its share of opportunities and threats to the final quality of the green bean. Understanding potential postharvesting processing errors allows for better quality management.

On one hand, proper post-harvest processing avoids unnecessary mistakes resulting in potential quality claims and price penalties. On the other, it secures consistent quality as well as the production of coffees with good cup profiles, capable of logging attractive prices.<sup>1</sup>

The moisture content of ripe cherries at harvest is around 65%. The rationale behind post-harvest processing is to reduce the moisture content 11%–12% through drying and then removing the outer coverings (exocarp and endocarp) from the beans. Drying can be done by open air, solar or mechanical drying (electric). This manual will however focus on open-air and solar drying. These drying methods are the most suitable for smallholder farmers who are the target of this manual.

Several methods are used to process harvested coffee cherries. The commonest processing methods used globally are natural (dry), washed (wet), and pulped natural (honey) – see Figure 1 and Table 3. In West Africa and Robusta production, natural (dry) processing is usually used.

<sup>1</sup> International Trade Centre (2021). The Coffee Guide. ITC, Geneva.

**Figure 1 An overview of coffee processing**

**Table 3 Three primary coffee processing methods**

<b>Process Step</b>	<b>Natural method (dry)</b>	<b>Washed method (wet)</b>	<b>Pulped natural method (honey)</b>	<b>Impact and risks</b>
State of the coffee beans: In the fruit or parchment				
<b>Harvesting</b>	Selective versus strip-picking. Different types of mechanization (manual, semi-mechanized, fully mechanized).			Can cause defects such as bruising.
<b>Reception</b>	Reception of cherries at the processing facilities – ideally within eight hours after harvesting, the shorter, the better. Sorting by hand in some countries when manually harvested.			Can cause defects such as bruising.
<b>Shaded</b>	Precleaning, sorting and separation of stones and impurities and grading of cherries according to density in siphon tanks or mechanical siphons. Hydraulic separation or floatation. Further precleaning measures such as size grading of fruit, winnowing and sieving are possible.			Removal of defects such as light beans.
<b>Drying cherries</b>	Drying cherries on raised beds or on patios by raking and turning for 14–21 days or mechanically. The final moisture level is 11%–12%. The skin turns black.			Can cause defects if the cherries are not turned regularly to prevent fermentation and to allow uniform drying, if the drying rate is too low due to high relative humidity or other factors, and if temperatures exceed the recommended limit. A critical stage in the process where undesirable aromas may develop.
<b>Mechanical pulping</b>		Mechanical pulping, with or without unripe cherry separation. Skin and fruit flesh are removed, leaving the beans in the sticky mucilage.	Mechanical pulping, with or without unripe cherry separation. Skin and fruit flesh are removed, leaving the beans in the sticky mucilage.	High-quality pulpers reduce the percentage of waste. Can cause defects such as pulper cuts.
<b>Mucilage removal</b>			The sticky mucilage may be left or partly removed by a mucilage remover.	Can cause defects.
<b>Fermentation</b>		Fermentation in tanks for 10 to 48 hours; can be shorter or longer. The sticky mucilage is broken down by microbes. Mechanical mucilage removal can follow or even replace fermentation (saving water).		<b>Note:</b> It is not the coffee bean itself, but the mucilage on the parchment that is removed through fermentation.
<b>Washing</b>		Washing off any remaining mucilage particles. Can be combined with sorting.		Can cause defects.
<b>Drying</b>		Drying of parchment for 8–15 days on patios or on mesh tables, or mechanically at around 40°C (105°F). The final moisture level should be 11%–12%.	Drying of parchment for 8–15 days on patios or on mesh tables, or mechanically at around 40°C (105°F). The final moisture level should be 11%–12%.	Can cause defects if drying is done too fast or too slow and if temperature exceeds the recommended upper limit. Parchment must be turned regularly to prevent fermentation. One of the most critical phases in the preservation of quality.

Process Step	Natural method (dry)	Washed method (wet)	Pulped natural method (honey)	Impact and risks
Resting	Resting (also called curing, conditioning, storage) in silos for 15–60 days to homogenize moisture, enhance quality attributes and ensure better ageing. The resting can be longer for naturals than for coffee in parchment.			Can cause defects and greenish flavours if moisture content is not controlled. Failure to control moisture content may result in loss of quality and possible mould contamination.
Precleaning and destoning	Removal of foreign matter, sometimes also with magnets for iron pieces.			Removal of impurities and defects.
State of the coffee beans: <b>Green beans</b> Processes are adapted to roasters' specifications				
Hulling or milling	Removal of dried cherry skin with the help of a cross-beater or a friction huller. Equipment must be accurately calibrated for bean size. Polishing in friction machines is optional, but not recommended for Arabica.	Removal of parchment and silver skin by friction equipment. Polishing in friction machines is optional, but not recommended for Arabica.	Removal of parchment and silver skin by friction equipment. Equipment must be accurately calibrated for bean size.	Can cause defects such as breakage.
Air cleaning	Air cleaning in airflow, removing dust.			Can discard light beans and impurities/ hull remnants.
Sorting	Sorting by bean size via screening (same size enables uniform roasting at a later stage).			Can cause defects.
Sorting by bean density	Sorting by bean density on shaking densimetric tables. Dense (and best) beans climb to the top (same density secures uniform roasting at a later stage).			Removal of defects.
Sorting by colour	Sorting by colour – manually or optically.			Removal of defects.
Quality evaluation and classification	Quality evaluation and classification – visually and by cupping.			–
Blending	Blending of different sizes and qualities to meet client requirements.			–
Bagging off	Bagging off or sending to bulk silos.			Can be contaminated by foreign odours.
Shipping in container	On trucks and vessels, either in bags or in bulk.			Fungus risk from temperature and humidity fluctuations.
Storage	Storage in bags or in silos – often by a trading house and later at the roaster's premises.			Can be contaminated by foreign odours.
Blending	Performed to meet client quality and bean size requirements. For optimal roasting, the beans must have the same size, density and moisture content. (Blending after roasting (split-roasting) is also possible but less common and primarily used for high quality coffees.)			Causes defects at roasting if beans are not homogeneous.

Source: *The Coffee Guide*, International Trade Centre (2021).

## Natural (dry) processing

The harvested cherries are dried and hulled to remove the entire dried husk (exocarp, mesocarp and endocarp) to obtain green coffee. Drying can be done using open-air drying (sun drying), mechanical (electric) or solar drying. Sun drying is more common and less expensive. The cherries are dried to a moisture content of 11–12% or when the dried cherries make a rattling sound when shaken in the fist.

Recommended practices to adopt and avoid are provided in Tables 4 and 5.

**Table 4 Open-air (sun) drying: Practices to adopt and avoid**

Recommended good practices	Bad practices ( Food safety and quality issues)
	

- Spread the harvested cherries on a raised mat, known as a drying bed, that allows air to pass through. This reduces contamination from the floor and animals.
- Spread the cherries thinly on the raised mat (not more than 3 cm thick) to ensure rapid drying and prevent mould growth.
- Turn the cherries regularly to ensure uniform drying.
- Pick out bad cherries and other foreign materials during the drying process.
- Cover cherries with polythene or a roofing sheet at sunset and before it rains to prevent delayed drying which could lead to mould growth with its associated mycotoxin contamination.
- Process cherries for drying soon after harvesting.

- Drying on the floor exposes the cherries to physical and microbial contamination from animal droppings and dust. The cherries can absorb odour from the concrete floor.
- More labour is required for collecting and re-spreading during bad weather.
- Keeping wet cherries for long and especially under anaerobic conditions leads to unwanted and uncontrolled fermentation.

**Table 5 Tent (solar) drying: Basics**

	
<ul style="list-style-type: none"> <li>■ Using solar tents eliminates the chances of cherries being wet by the rain, which leads to mould growth and mycotoxin contamination.</li> <li>■ Different materials can be used in constructing the solar tent e.g. transparent glass, perspex, polythene, etc.</li> <li>■ Ensure there is air circulation (inflow at the bottom and outflow at the top) to prevent condensation.</li> <li>■ Solar tents leads to a faster drying period. However, an excessively high temperature in the tent can lead to cracked beans.</li> </ul>	

**KYE MESSAGE**

*It is important to process the cherries for drying soon after harvesting. Keeping wet cherries for long and especially under anaerobic conditions leads to unwanted and uncontrolled fermentation. Fermentation results in stinky beans with a negative cup effect.*

The first step to any processing method is sorting and separating the cherries. In West Africa, this is usually done manually. However, it can also be done through immersion of the cherries in water, a technique known as “floatation”. The two methods are outlined below.

**Sorting and separating the cherries**

Manual sorting is a common practice in West Africa. Bad cherries and other foreign materials are picked out during the drying process, from the drying beds where the cherries are spread out.

The advantage is that the process eliminates the use of water. The disadvantage is that it is a difficult and unreliable method to ensure that bad (overripe or unripe) cherries and debris are removed. This method produces Fair Average Quality beans. Overripe and unripe cherries have a negative impact on the cupping flavour and taste of coffee.

Key pros and cons are captured in Figure 2.

**Figure 2 Pros and cons of manual sorting**

Advantages	Disadvantages
<ul style="list-style-type: none"> <li>• It can be done on a large scale</li> <li>• The method is environmentally friendly</li> <li>• Does not require the use of excess water</li> <li>• The method is cost-effective</li> </ul>	<ul style="list-style-type: none"> <li>• Difficult to separate bad cherries (such as over-ripe, unripe, etc.) from the matured ripe ones.</li> <li>• Results in fair average quality beans.</li> </ul>

Floatation is a sorting technique that uses immersion in water to sort and separate the cherries. Harvested cherries are steeped in a tank of water. Poor quality cherries as well as debris from harvesting float, while the good quality cherries sink. The sorted beans are then de-pulped to obtain the beans for drying. An overview is provided in Table 6.

Water is used to remove impurities and separate the coffee fruit. This can be done using static water containers (buckets or larger tanks), grading channels, siphon tanks or mechanical washerseparators that recycle and save water. Hydraulic separation traditionally provides a separation into floaters and sinkers.

Floater:

- Less-dense impurities such as leaves and twigs
- Dried-on-tree coffee and some overripe fruit
- Ripe, semi-ripe and unripe coffee fruit that is less dense because of pest or disease attacks or lack of bean development.

Sinkers:

- Ripe and green coffee cherries

The advantage is that this is an effective way of sorting coffee cherries from the start and ensuring that the cherries retained for the rest of the processing are of high quality, resulting in a high quality final product.

The disadvantage is that this method is less water-efficient, which can be taken into account in case of periods of water-stress.

Key pros and cons are captured in Figure 3.

**Table 6 The floatation sorting method**



- Immerse the harvested cherries in a pool/tank of water.
- The matured ripe cherries will sink (sinkers) in the water while over ripe, immature and defective cherries float (floaters) on the water.
- Scoop the floaters from the water, leaving the sinkers.
- The floaters can also be processed as second-class beans.
- De-pulp the sinkers. De-pulping involves the mechanical removal of the pulp from the coffee cherries to have parchment coffee.
- The de-pulped cherries are then dried as recommended in tables 4 and 5.

**Figure 3 Pros and cons of floatation sorting**

Advantages	Disadvantages
<ul style="list-style-type: none"> <li>● Separates mature cherries from overripe, rotten and under ripe cherries</li> <li>● Farmer has two products, high quality and low quality well segregated for target market</li> <li>● Reduces time spent in picking out bad cherries and debris</li> </ul>	<ul style="list-style-type: none"> <li>● Labor intensive</li> <li>● Extra cost in providing the tanks in addition to the water</li> <li>● Water disposal could have negative environmental impact</li> </ul>

## Hulling

Hulling involves the removal of the husk (exocarp, mesocarp and endocarp) of dried cherries to obtain green coffee. It is done using hulling machines. Practices to adopt and avoid are captured in Table 7.

**Table 7 Hulling: Practices to adopt and avoid**

Recommended good practices	Bad practices ( Food safety and quality issues)
	
<ul style="list-style-type: none"> <li>■ Check the moisture content of the dried cherries before hulling.</li> <li>■ Moisture content should be 11-12% or the dried cherries makes a rattling sound when shaken in the fist.</li> <li>■ Turn on the hulling machine and pour the dried cherries into the machine.</li> <li>■ Hull the cherries and collect the hulled beans in a container or bowl.</li> <li>■ Repeat the hulling process when necessary to enhance the physical appearance of the beans.</li> <li>■ Winnow the hulled beans to remove the remaining husk.</li> <li>■ Clean the hulling machine before and after use.</li> </ul>	<ul style="list-style-type: none"> <li>■ The hulled beans are collected in a dug-out concrete pit. Collecting the hulled beans from the dug-out concrete pit could lead to contamination of the beans</li> </ul>

**KYE MESSAGE**

*Hulled beans expose bad-quality cherries. Unripe cherries do not turn out as bright, while rotten or over-ripe cherries come out darker than ripe cherries.*

*Effective dry cleaning of the huller to avoid film coats and collection of coffee within the machine (corners and crevices) that could serve as microbial niches to contaminate products.*

*Food-grade oil should be used to grease the hulling machine.*

**Sorting and grading**

Hulling involves the removal of the husk (exocarp, mesocarp and endocarp) of dried cherries to obtain green coffee. The aspect of the green coffee is paramount, as it is the first impression a buyer gets. Depending on the impression, a buyer may decide to assess the coffee quality further or skip the sample and buy elsewhere.

The green coffee assessment has several steps. The beans' colour and appearance are evaluated, along with an olfactory (smell) check. This is followed by a humidity and water

activity analysis. Screen-size analysis and defect counting are paramount in any coffee quality assurance lab today.

Sorting involves the removal of undesirable, immature, black beans, and foreign contaminants from hulled beans. Sorting is meant to remove impurities and poor-quality beans from the lot. Green beans are then graded by size to obtain uniform beans.

Classification systems have criteria such as:

- Processing method
- Screen size
- Number of defects
- Altitude
- Density
- Region
- Variety
- Cup quality



Sorting green coffee.

#### *Basic sorting best practices and information*

- Spread hulled beans thinly on a flat surface
- Sort by picking out broken, diseased, insect-infested, immature, and black beans
- Dark-coloured beans are from immature cherries and should be picked out because
  - They result in a poor cup quality
  - They can be roasted separately as second-class coffee

- Defective beans affect the cup quality

Green coffee defects directly affect the roasted coffee's quality and appearance and, hence, the final product.

Defects are usually categorized as follows:

- Primary (or type 1) defects: significant impact on the cup
- Secondary (or type 2) defects: minor impact on the cup

**Table 8 Examples of primary defects**

	Possible impact on roasting	Possible effect on beverage taste
Fully black	Slow, with light beans	Highly bitter, dirty, phenolic
Fully sour	Slow and irregular	Acrid, pungent, fermented, sour
Fermented sour	Irregular	Fermented, sour, unpleasant smell
Presence of foreign matter (stones, wood)	Irregular	Abnormal, unpleasant tastes
Presence of dried cherries	Irregular	Phenolic, fermented, mouldy

**Figure 4 What do coffee bean defects look like?**



Source: *Coffee Sapiens*, Adrià, elBullifoundation and Lavazza (2019).



Coffee Bean Size Classification

#### *Basic size grading information*

- Green coffee is graded and classified for the market
- Grade the beans by size using perforated plates (screens)
- Screen sizes used are measured in 1/64 inches. Most green beans range between 12–19 screens
- Grading is done:
  - To produce homogenous commercial lots that meet defined quality criteria
  - To facilitate a fair system of pricing

#### **Box 2 Screen sizes**

Coffee is graded by size using rotating or shaking screens, replaceable metal sheets that have holes that retain beans over a certain size and allow smaller beans to pass. Screen sizes are expressed as numbers (e.g. Robusta grade one screen 16), by letters (e.g. Arabica grade AA – indicating a bold bean) or by descriptions (e.g. bold, medium or small bean).

Intermediate screen sizes (e.g. 16.5) are important in some producing countries, but disregarded in others. However, nearly all coffee for export is graded to exclude the largest and smallest beans, as well as broken beans and other particles.

It is not always easy or possible to achieve a 100% accurate screen (e.g. nil passing through screen 16). Where a 100% accurate screen is required, then marginally increasing the hole size to give a small tolerance in the screen may provide the required result.

Slotted screens with oblong slits (usually 4mm or 4.5mm wide) are used in some countries to remove peaberries (single oblong beans in a cherry, the result of a genetic aberration because normally there are two beans in a cherry), which are sought after in some consuming countries.

#### **Standard coffee round screen dimensions**

Screen number	10	12	13	14	15	16	17	18	19	20
ISO dimensions (mm)	4.00	4.75	5.00	5.60	6.00	6.30	6.70	7.10	7.50	8.00

Source: *The Coffee Guide*, International Trade Centre (2021).

There are 5 grades determined by bean size:

<b>Grade 0</b>	Beans held back by screen No. 18 (7 mm holes)
<b>Grade I</b>	Beans passing through screen No. 18 and held back by screen No. 16 (6.3 mm holes)
<b>Grade II</b>	Beans passing through screen No. 16 and held back by screen No. 14 (5.5 mm holes)
<b>Grade III</b>	Beans passing through screen No. 14 and held back by screen No. 12 (4.7 mm holes)
<b>Grade IV</b>	Beans passing through screen No. 12 and held back by screen No. 10 (4mm holes)

Source: FAO (2000).

### Bagging and storage of green coffee

Coffee storing techniques of green coffee will directly impact the quality of the final consumer product. Bad practices can damage the coffee in many ways. Table 9 provides a summary of basic practices to adopt and avoid when it comes to green coffee storage.

**Table 9 Storage: Basic practices to adopt and avoid**

Recommended good practices	Bad practices (Food safety and quality issues)
 <ul style="list-style-type: none"> <li>Store the hulled coffee in jute sacks</li> <li>Place the bags of coffee on pallets in a well-ventilated room</li> <li>The pallets should be kept away from the walls of the storeroom</li> <li>Store the coffee beans in dedicated storerooms with no other products</li> <li>The storeroom should be protected from water, smoke, insects, and rodents</li> </ul>	 <ul style="list-style-type: none"> <li>The hulled beans are stored in plastic sacks</li> <li>This will lead to the re-absorption of moisture</li> <li>The beans are stored with other commodities and substances</li> <li>The bags of coffee are placed on the bare floor</li> </ul>

**KYE MESSAGE**

- *Dried unhulled coffee beans could also be stored immediately after drying*
- *These should also be stored in jute sacks placed on pallets in a well-ventilated room (as done for the hulled beans)*
- *However, prolonged storage of the unhulled beans can adversely affect quality. Coffee should be hulled immediately after drying*

**Roasting**

This involves transforming the green coffee into aromatic brown beans by subjecting it to high temperature in a roaster. Roasting allows different aromas to develop over time, depending on the coffee type used. There are different types of roast (light, medium, dark and varying degrees in between) that aim to bring out the coffee qualities and meet consumer preferences.

Sample roasting is an essential component of the quality-control process at all points along the supply chain, starting from origin. This is helpful for buyers, producers, importers and roasters.

**Box 3 Sample roasting**

- Sample roasting is an opportunity to evaluate the green coffee's quality and uniformity. It can provide valuable feedback to producers, showcase coffee to potential buyers and aid in production development processes.
- Sample roasting also provides quality assurance on inventory checks, age and any profile changes that need to be made.
- When evaluating coffee for quality purposes, it is important to have a consistent, non-biased and uniform roast to concentrate on the coffee attributes versus the roast profile. The main goal of this process is to uncover any defects that were not revealed in the previous green bean evaluation. Roasting brings out the aroma and flavour that is locked inside the green coffee beans. It causes chemical changes to take place as the beans are rapidly brought to very high temperatures.

**Source:** *The Coffee Guide, International Trade Centre (2021)*.

Coffee roasts are identified by their colour: light, medium and dark. Although these are not the most accurate terms for describing different roasts, as some coffees are naturally darker or lighter than others, they are convenient ways to categorize roasts.

**Box 4 Roast categories**

- Light roasts retain most of the original coffee characteristics. They have a light brown or tan colour and the roasted beans lack oil. They have the highest acidity and are the brightest of the three roast levels. The characteristics of different origins are most pronounced in light roasts, as are the qualities of the individual coffees.
- A light roast also makes it easier to spot immature and green beans, which are pale yellow in colour rather than brown when roasted. Much of the taste comes from the original coffee, which is why light roasts are often used for cuppings. Light roasts are sometimes called Half City, Light City, New England or Cinnamon roasts.
- Medium roasts balance acidity and body. A medium roast has a darker brown colour than a light roast and looks richer. Some of the coffee's oils may be visible on the beans, as well. At this roast level, the coffee's qualities begin to give way to the roast's flavours and aromas, creating a balance between acidity and body. The original coffee taste is still discernable, but the brightness of the beans is complemented by the fuller body that is introduced by the roasting process. Medium roasts go by City, Breakfast, Regular and American roasts.

- Dark roasts showcase bold bodies and a richer taste. They are dark brown, sometimes almost black. Oils can be seen on the beans at this point. Dark roasts obscure the finer aspects and are often used to cover up defects. When roasting beans of the same quality, a light roast brings out more brightness in the cup, while a dark roast accentuates body. Because the original coffee's qualities are mostly lost at this roast level, it's difficult to pick out the characteristics of a specific coffee's origin or lot.

Source: *The Coffee Guide, International Trade Centre (2021)*.

**Table 10 Roasting: Basic practices to adopt and avoid**

Recommended good practices	Bad practices (Food safety and quality issues)
	
<ul style="list-style-type: none"> <li>Involves the use of roasters made of materials (e.g. stainless steel) that do not pose food safety risks through rusting or wear and tear</li> <li>Roasters are equipped with a thermometer on the drum or thermometer probes to measure roasting temperatures</li> <li>The fire source is enclosed with heat-resistant materials such as bricks to minimize heat loss during roasting</li> <li>Roast beans of uniform size and weight. This ensures uniform roasting and hence better-quality coffee, without the burnt taste in the cup.</li> <li>Roast beans from different farms, agents, and regions separately to enable traceability.</li> </ul>	<ul style="list-style-type: none"> <li>Involves the use of locally fabricated roasters and frying pans, which are not equipped with temperature gauges.</li> <li>Orthodox means and experience are used to determine roasting quality and endpoints</li> <li>Roasting is started at high heat until the flavour begins to come out to indicate the beans are roasting. The heat is then reduced for about 30 min until smoke begins to come out to indicate the coffee is roasted. The use of smoke to indicate the endpoint of roasting could lead to charring of coffee</li> <li>Roasting in pans could lead to dust, ash, and smoke contamination of the roasted coffee since roasting is done in the open and the pan is not closed.</li> <li>Metal contamination of the roasted coffee from the metallic rotating drum roaster.</li> </ul>

## Grinding (milling)

This involves particle size reduction of the roasted coffee. Grinding can be coarse, medium or fine-ground. Grinding is the process of transforming the roasted beans to coffee powder, fragments or small granules by applying mechanical forces, in preparation for the next phase of elaboration.

Ground coffee quality can be defined as the correct quantity and quality of components retained by the roasted bean and available for extraction, regardless of whether it is intended for further elaboration or for the packaging process. The grinding operation makes a fundamental contribution to the final product's quality (*The Coffee Guide*, International Trade centre, 2021).

**Table 11    Grinding (milling): Basic practices to adopt and avoid**

Recommended good practices	Bad practices ( Food safety and quality issues)
	

**Recommended good practices:**

- Use grinders/ mills made from stainless steel materials to avoid metal wear and tear with resulting metal contamination
- Grinders/ mills should be solely dedicated to the grinding/ milling of roasted coffee
- Use clean bowls or containers to collect the ground/ milled coffee
- Clean the mill thoroughly before and after use
- Use only food-grade oil/grease to grease the grinder/ mill

**Bad practices (Food safety and quality issues):**

- Involves the use of a disc attrition grinder/ mill made from cast iron
- These grinders/ mills are highly susceptible to wear and tear leading to metal contamination
- The mills are normally used to grind/ mill cereals and other foods
- Using commercial grinders/ mills can introduce contamination from previously milled foods
- Commercial grinders/ mills may not use food-grade grease.

## Packaging of roasted coffee beans

This involves packing roasted coffee (ground or in whole beans) into appropriate packaging materials (paper pouch, polypropylene bags). Improper packaging of roasted coffee beans can damage the beans and negatively affect the final consumer product.

### Box 5 Examples of different coffee bags

Sample bags:



30kg paper bags:



Standard 60kg and 69kg jute bags:



Standard 60kg jute bags with polyethylene inlay for better qualities:



1,500kg high barrier plastic big bag:



Source: *The Coffee Guide*, International Trade Centre (2021).



#### *Basic roasted coffee packaging best practices*

- Roasted coffee can be packed in sealed glass jars, plastic containers, polypropylene bags, and paper pouches.
- Adhere strictly to good manufacturing practices (GMP) and good hygienic practices (GHP) during and after packaging. Personnel filling packaging materials with coffee MUST wear an appropriate garment, hair cover, nose mask, and gloves; cover all open sores, etc.
- Always keep packaging room and materials clean.

#### *Storage of roasted coffee*

Storage of roasted coffee involves keeping roasted coffee (ground or whole beans) in a cool, dry place.

**Table 12 Storing roasted coffee: Basic practices to adopt and avoid**

Recommended good practices	Bad practices ( Food safety and quality issues)
	
<ul style="list-style-type: none"> <li>■ Store roasted coffee in a clean, well-ventilated room on raised platforms such as pallets or shelves.</li> <li>■ Store roasted coffee separately from green coffee.</li> <li>■ Store roasted coffee in a room without other food or non-food commodities as the beans can easily pick the flavour compounds.</li> <li>■ The storeroom should be protected from water, smoke, insects, and rodents.</li> </ul>	<ul style="list-style-type: none"> <li>■ Roasted coffee (ground or whole) is stored in the kitchen with other foodstuffs as well as in other rooms with other items such as the hulled beans and packaging materials.</li> <li>■ This could result in possible contamination in terms of safety and flavour.</li> </ul>

## Chapter 2

# Good Manufacturing Practices and Food Safety

Food safety has become a central issue in the coffee industry in recent years, with most countries regulating and inspecting importers and roasters.

Good Manufacturing Practices (GMP) guidelines are general principles that must be observed during manufacturing. They provide guidance on post-harvest processes such as washed or natural processing, manufacturing, testing and quality assurance to ensure that a manufactured product is safe for human consumption or use. Many countries have legislated that producers follow GMP procedures and/or created their own GMP guidelines that correspond with their legislation.<sup>2</sup>



GMP guidelines are not prescriptive instructions on how to manufacture products. When a firm sets up its quality programme and manufacturing process, there may be many ways for it to fulfil GMP requirements.

The company itself must determine the most effective and efficient quality process that meets both business and regulatory needs.

All GMP guidelines should follow these basic principles:

**Employees:** This includes personal hygiene, hand washing, hair restraints, no personal items near open food, no food or drink.

- **Processing facility:** Good condition of building, no leaks, cracks, smooth cleanable walls, surfaces and floors, cleaning of all facilities and surfaces on a regular basis, pest control programme, grounds maintained, proper plumbing, bathrooms, sinks and maintenance of everything.
- **Processing equipment:** Approved for food use, cleaned and sanitized, maintenance programme, proper equipment and trained employees.
- **Warehouse and distribution:** Storage and transportation shall be under conditions that protect food against physical, chemical and microbial contamination as well as against deterioration of the food and food

<sup>2</sup> International Trade Centre (2021). The Coffee Guide. ITC, Geneva.

containers.<sup>3</sup>

GMPs are recommended to safeguard consumer health and to produce quality items. All food business operators should follow them. GMPs are the foundation of a food safety plan and are, in theory, in effect at all times. They are not specific to one hazard. They are also the minimum policies and procedures one should have in place.<sup>4</sup>

Extensive, detailed information on Good Manufacturing Practices and food safety in the coffee value chain can be accessed in Chapter 5 of ITC's Coffee Guide, 4<sup>th</sup> Edition.

## Raw material handling

Raw material for processing could either be

- a. Dried cherries
- b. Green beans

Develop specifications for your raw material. This should include:

- Physical characteristics
  - Size, shape, colour, level of brokenness, moisture content
- Microbiological characteristics
  - Mould contamination, other microbial leads where necessary
- Chemical Characteristics
  - Mycotoxin, pesticides, etc.

The quality of the raw material is crucial to ensure the safety and quality of the final product.

- Select only good quality beans for processing.
- Good quality beans entail:
  - A uniform, golden colour (off-colour beans lead to poor-quality coffee when brewed)
  - Sorted to uniform size
  - Dried to 12% moisture
  - Free of mould
  - Broken beans should be sorted and processed separately as second grade

Characteristics of good quality beans and best storage practices are discussed in chapter 1 of this manual.

- Store raw coffee beans for processing in batches.
- The batch should be traceable to a supplier or farm from which these beans are sourced.
- Store in jute sacks, in a cool dry place, on pallets and away from the wall.
- The storeroom should be free from pests and chemicals that can taint the coffee.
- Keep a record of receipt from and issuance of beans for processing.

## Plant design and structural requirements

### Selection of a factory site

- Ensure a clean environment, free from environmental pollution such as dust and chemicals.
- Avoid siting processing plants close to environments of high industrial pollution.

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3 International Trade Centre (2021). The Coffee Guide. ITC, Geneva.

4 International Trade Centre (2021). The Coffee Guide. ITC, Geneva.

- Make provision for:
  - Raw material storage
  - Processing area
- Have a physical separation of hulling activities from roasting and milling.
- Hulling is a relatively dirty process and can lead to the contamination of roasted beans.
  - Finished product storage
  - Changing room for staff
  - Toilet facilities for staff: These should be physically separated from the processing facility, and doors and windows should not open directly into storerooms or processing areas.
- Use durable materials for the building for easy maintenance, cleaning, and disinfection.
- Provide adequate ventilation and good lighting.
- Clear demarcations should be observed where there are no physical barriers, ideally using floor markings.

## Construction materials

### Floor

- Smooth, impervious, and easy to clean. e.g. epoxy painting, terrazzo, tiles, or smooth screeding.
- Drains (if any) should flow from clean to dirty operational areas.
  - They must be smooth, impervious, and easy to clean.
  - Covered drains are preferred.
  - Ends should be covered to prevent the ingress of rodents.

### Walls

- Must be smooth, impervious, and easy to clean.
- Should have a light-coloured finishing, paint or tiles are acceptable.
- If possible, all corners should be curved instead of 90 degrees turns.
- Avoid wall ends and shoulders that can accumulate dirt and dust.

### Windows and doors

- Doors and windows should be screened against pests and insects.
- Doors should ideally be self-closing, opening to both sides and without handles i.e., push-to-open.
- All openings in the doors and windows should be sealed to prevent harbourage for pests.

### Roof and ceiling

Where there is a ceiling, it should:

- Be smooth, light-coloured and easy to clean.
- Not enable harbourage for pests.
- Have clean fittings, restricted to essentials only.
- Not have light bulbs fixed directly over open foods or machinery. They should have a shatterproof covering.

Where there is no ceiling:

- The roof should always be kept clean.

- Eaves should be sealed to prevent the entry of pests, birds and rodents.
- All openings in the roof and ceilings should be sealed properly to prevent the harbourage of pests.

## Process flow

- Process flow should be positive from raw material entry to finished products exit.
- This could be linear or horseshoe.
- Criss-crossing process flow leads to cross-contamination.

### Linear

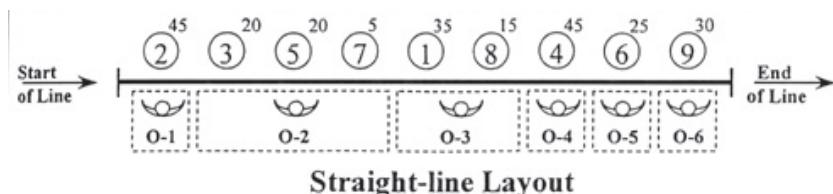
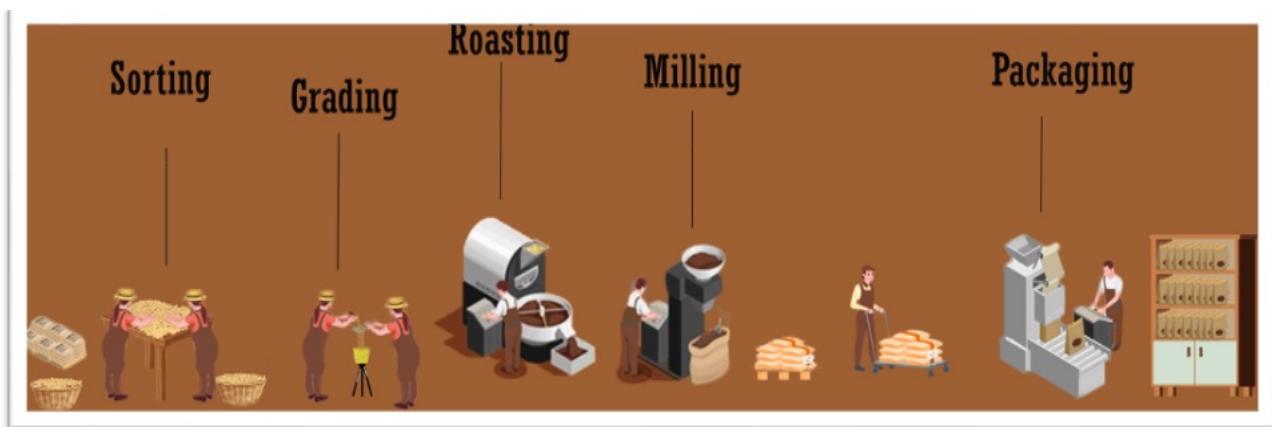
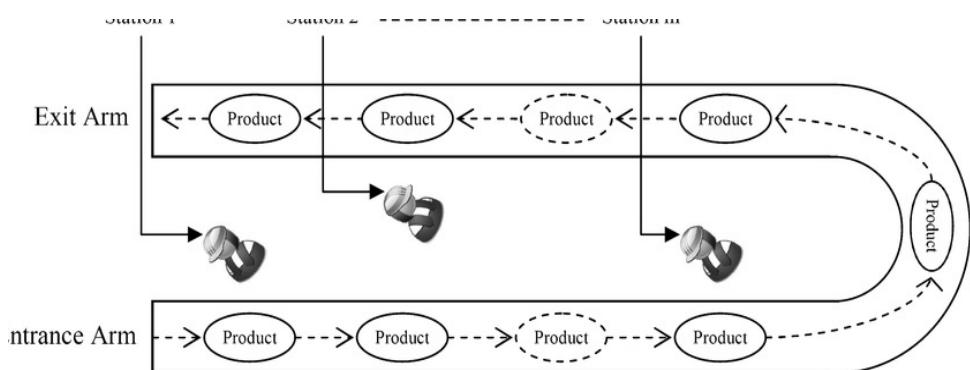
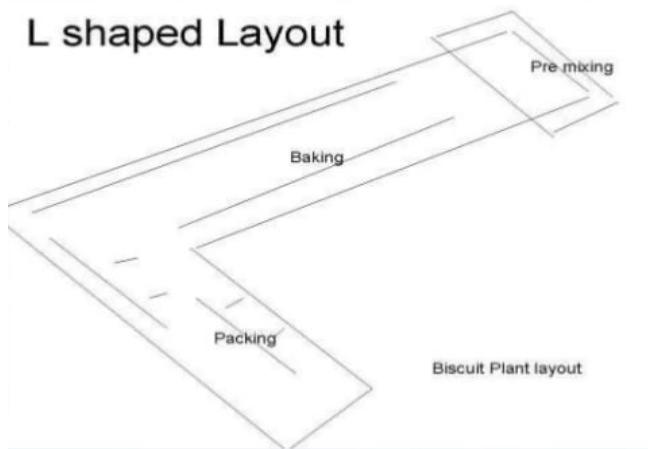
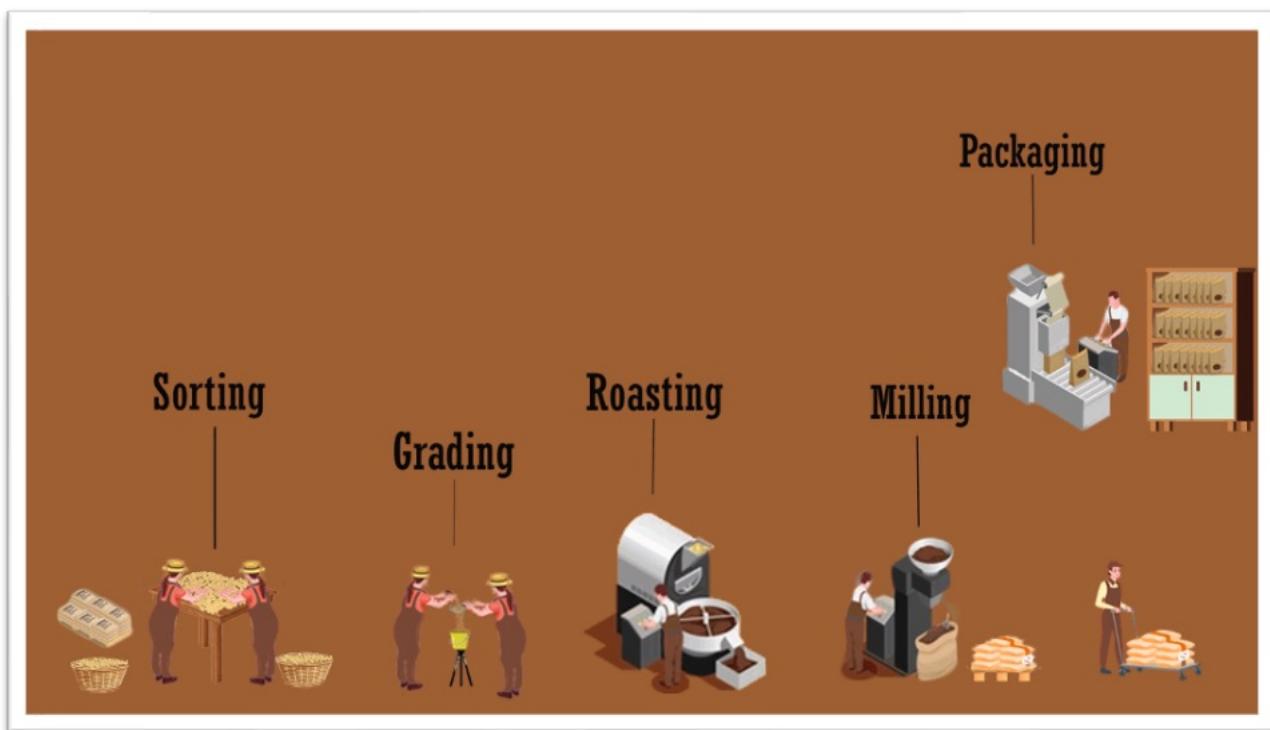


Figure 5 Linear (straight-line)-shaped layout



Source:



**Figure 6 U-shaped layout****Figure 7 L-shaped layout**

### Prevention of cross-contamination

- Clear separation of high-risk (clean processing) and low-risk (dirty processing) operations
- Use of recommended food contact surfaces
- Colour coding of personnel
- Colour coding of tools and containers

### Waste disposal systems

- Coffee husks obtained during hulling of dried coffee cherries could be collected dried and processed further into animal feed.

- They could also be used as substrates for mushroom cultivation or the generation of biogas.

## Personal hygiene

Coffee processors should maintain a high level of hygiene and cleanliness throughout the entire process. The following hand-washing regimes should be strictly observed by personnel:

- At the start of the processing
- At the end of every unit operation and before commencing another unit operation
- Immediately after using the washroom
- After handling any material which could lead to contamination of products

## Personnel issues

- Hygiene training
- Work apparel (overcoats, head gears, nose mask, and footwear)
- Personal hygiene (short nails, ideally short hairs, clean shave, control of jewellery)
- Managing sickness and cuts (report all forms of sickness to manager/supervisor, no entry of food processing areas for persons with cold, boils or diarrhoea, cuts and wounds should be well covered)
- Annual health screening (Food Handlers Test)
- No smoking, spitting, chewing (of gum), sneezing or coughing near unprotected food materials
- Visitors to the processing plant must wear protective clothing and adhere to all personal hygiene requirements.

## Maintenance of processing equipment

- Processing equipment should be well maintained to ensure they function as intended, prevent contamination as well as prevent equipment breakdown.
- Equipment should be made from food-grade materials to prevent metal contamination.
- Food-grade lubricants should be used to grease all metal parts to avoid contamination.
- Develop and implement a preventive maintenance Schedule.

## Workplace organisation using the principles of 5S

### Box 6 What is 5S?

5S is a principle of work environment improvement derived from the Japanese word Seiri (Sort), Seiton (Set), Seiso (Shine), Seiketsu (Standardized) and Shitsuke (Sustain).

It is an efficient workplace organisation that is aimed at simplifying work environment, reducing waste and non-value activity, while improving quality, efficiency and safety.

**Source:** International Trade Centre

**Table 13 5S terminologies explained**

Japanese	Translated	English	Definition
Seiri	Organize	Sort	Eliminate whatever is not needed by separating needed tools, parts, and instructions from unneeded materials.
Seiton	Orderliness	Set in order	Organize whatever remains by neatly arranging and identifying parts and tools for ease of use
Seiso	Cleanliness	Shine	Clean the work by conducting a clean-up campaign
Seiketsu	Standardize	Standardize	Schedule regular cleaning and maintenance by conducting seiri, seiton, and seiso daily
Shitsuke	Discipline	Sustain	Make 5S a way of life by forming the habit of always following the first four S's

**Table 14 Organizational checklist for 5S**

Category	Item	Rating					Remarks
		L0	L1	L2	L3	L4	
Sort (organise)	Distinguish between what is needed and what is not needed						
	Unneeded equipment, tools, furniture, etc are present						
	Unneeded items are on the wall, ceiling, etc						
	Items are present in aisles, stairways, corners, etc						
	Unneeded inventory, supplies, art works, etc						
Set -in-order (Orderliness)	A place for everything and everything in its place						
	Correct place of items is not observed						
	Items are not in their place						
	Items are not put away immediately after use						
Shine (Cleanliness)	Cleaning and looking for ways to keep it clean and organised						
	Floors, walls, ceilings, stairways are not free from dirt, oil and grease						
	Equipment are not kept clean and free from dirt, oil and grease						
	Cleaning materials are not easily accessible						
	Lines, labels, signs, etc are not clean and unbroken						
	Other cleaning problems of any kind are present						

<b>Standardized (adherence)</b>	Maintain and monitor the first 3 steps							
	Necessary information is not available							
	All standards are not known and visible							
	Checklist does not exist for cleaning and maintenance jobs							
	All quantities and limits are not easily recognisable							
	How many items cannot be located within 30 seconds							
<b>Sustain (self-discipline)</b>	Stick to the rules							
	How many workers have not had 5S training?							
	How many times in last week was daily 5S not performed?							
	Number of times that personal belongings are not neatly stored							
	Number of times that job aids are not available or up-to-date							
	Number of times in last week that daily 5S inspections were not performed							
<b>Total</b>								

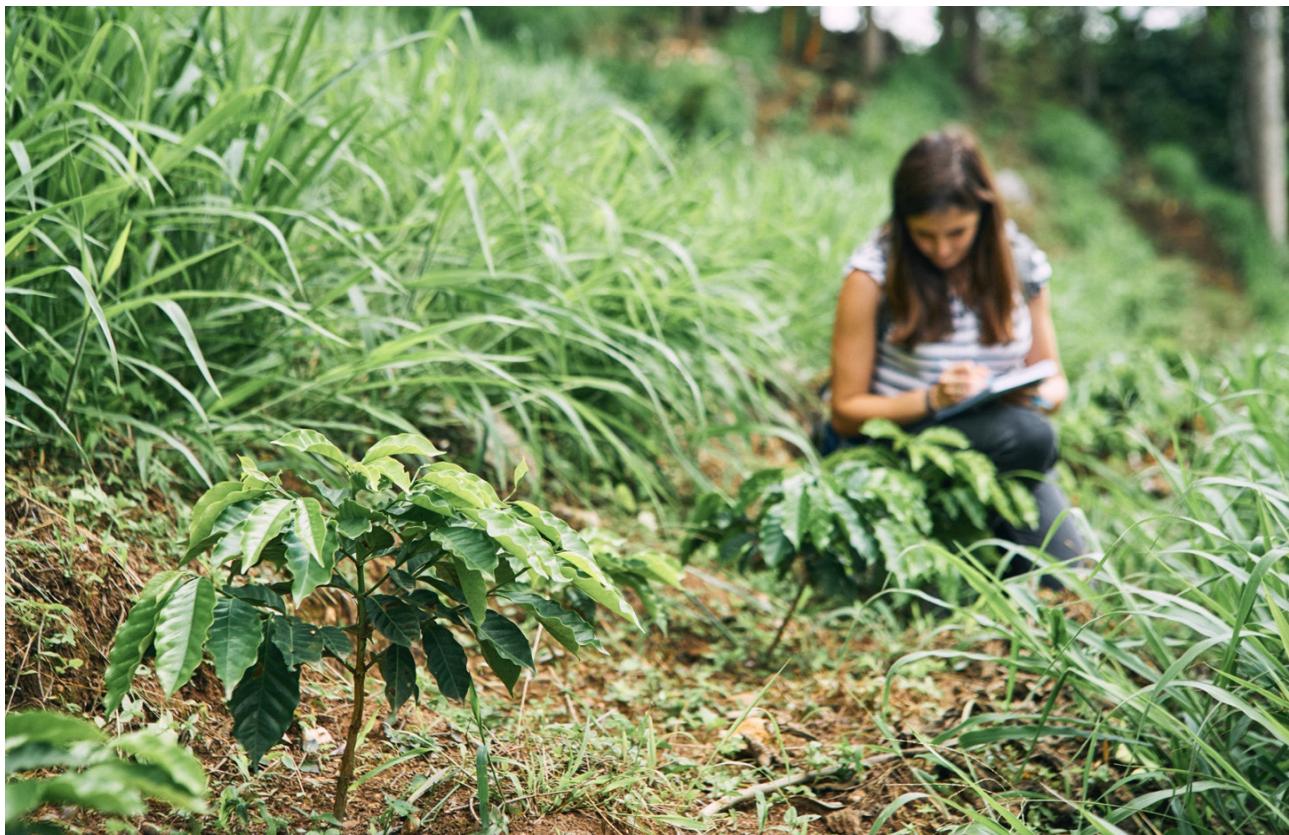
## Chapter 3

# Food Safety and Quality Management Systems

Food safety has become a central issue in the coffee industry in recent years, with most countries regulating and inspecting importers and roasters.

Quality control is essential, not only because of pricing considerations (better quality equals better price), but also to ensure that exports comply with food safety legislation in major import markets. It also helps to reduce waste and loss when coffee is harvested, processed and dried, and plays a role in the general move towards more sustainability in the industry.<sup>5</sup>

Chapter 5 of ITC's Coffee Guide, 4<sup>th</sup> Edition offers a detailed breakdown of coffee value chain food safety and quality management systems.



### Quality control in the supply chain: Where it begins

Quality control starts at the farm where the coffee fruits are produced and extends through each supply chain actor's respective steps until reaching the final consumer.

Quality control at the primary (farm-gate) level can assume different forms:

- Government or coffee authorities attempt to police harvesting, on-farm processing and drying. This is costly in terms of qualified staff and does not have a good track record
- Penalties are imposed for lower-than-average quality. This is passive quality control – it does nothing to encourage better than minimal or average quality.
- Premiums are offered for better-than-average quality. This is active quality control: it rewards and encourages the production of better quality. Premiums can be combined with a refusal to purchase lower quality, but this does leave open the question of what then happens to such coffees.

Different producing countries have different quality-control systems and attach different values to certain

<sup>5</sup> International Trade Centre (2021). The Coffee Guide. ITC, Geneva.

quality aspects. General information on coffee quality standards can be found at [www.iso.org](http://www.iso.org) (for instance, ISO 10470, a draft defect chart, but there are also many other ISO standards of interest to coffee exporters, including one detailing correct sampling procedures – under ICS 67.140.20 Coffee and coffee substitutes). Information is also available from coffee authorities in producing countries.

When setting quality limits, one should recognize that without active quality control, such as paying premiums for better quality, the maximum permissible limit (of defects, for instance) quickly becomes the new standard. And when setting export taxes, care should be taken not to penalize producers of better quality who manage to obtain premium prices as a result of their effort.<sup>6</sup>



## Quality Management Systems (QMS)

Quality Management System is a set of policies, processes and procedures required for planning and executing products in the core business area of an organisation that impacts its ability to meet customer and statutory requirements. The concept of QMS refers to both the documentation and its implementation. QMS is said to be implemented through the process approach. This means that the QMS implementation should enable the organisation to identify, measure, control and improve core business processes that will lead to improved business performance. The concept seeks to:

- i. Recognise the requirements of interested parties including customer and statutory requirements;
- ii. Ensure that these requirements are well met;
- iii. Confirm that employees receive appropriate and applicable training to facilitate implementation;
- iv. Determine processes, process inputs and outputs interactions between processes;
- v. Generate the needed evidence in the form of records that the system has been or is being met;
- vi. Monitor, measure and report performance;

<sup>6</sup> International Trade Centre (2021). The Coffee Guide. ITC, Geneva.

- vii. Plan changes to the system and take actions to address risks and opportunities;
- viii. Internal audit to analyse system performance;
- ix. Performance of corrective and preventive actions to ensure continual improvement of the system.

The ISO 9001 is the generic QMS standard for businesses and organisations. It is a systematic approach to QMS with auditable well-structured principles. It can be implemented in all organisations and across businesses.

## **Food Safety Management System (FSMS)**

FSMS is a systematic approach to managing (controlling) food safety hazards (food contaminants) within a food business in order to ensure that a given food is safe for consumption, if consumed according to intended purpose.

All food safety management systems are based on the principles of Hazard Analysis and Critical Control Points (HACCP). In other words, HACCP is the basic principles on which any food safety management system is built. It is an internationally accepted method to assuring food safety, i.e., ensuring that food is always safe for consumption through a systematic identification of food safety hazards at each process step and putting in control measure to eliminate or reduce the hazard to acceptable levels. The HACCP principles and its application to coffee processing is discussed later in this chapter. Specific FSMS standards include ISO 22000, FSSC 22000, IFS, BRC amongst others.

### **Policies**

A policy is simply a principle, guidelines, framework of action designed or adopted or proposed by an organisation to achieve its long-term goals. In other words, policies are a set of ideas or plans that are used as the basis for making organisational decisions. Examples of policies on Quality Management Systems includes Food Safety Policy, Health and safety Policy, non-smoking policy, etc. They are formulated to direct and exert influence on all the major decisions taken within the organisation thus setting boundaries within which activities are undertaken. Even though policies are not laws, they can be legally binding in some circumstances such as when they are incorporated in employee contract.

### **Specifications**

Specifications describe the characteristics of a product or an item in its exact desirable form.

Specification is required for raw materials, packaging materials and finished products. In some instances, specification will be desirable for in-process products. For instance, for a company that processes coffee from cherries to roasted and ground, specification is desirable for de-hulled beans as well as roasted beans in addition to fresh cherries and finished (ground) coffee.

Specifics to be included in specification are colour, texture, size, smoothness of beans, moisture content/water activity, microbial load, Maximum Residual Levels (MRLs) for agrochemical, mycotoxin levels, etc. Appendix 1 list some policies that are required in implementing a FSMS.

### **Standard Operating Procedures (SOPs)**

SOPs are designed to help a process achieve the same results. It gives instructive step-by-step approach to performing a function including operating a machine. SOPs should be in simple language to be understood by users, straight to the point and not too lengthy. Where appropriate, SOPs could be presented in pictorial forms with limited text.

SOPs are controlled documents. That is, they are documents that are issued and withdrawn through established line of authority within an organisation. It also means that they are identifiable by codes and revision numbers.

It is important that obsolete SOPs are traceable to the people to whom they are issued and withdrawn completely from the system. Appendix 2 offers some examples of SOPs in the coffee industry.

### **Traceability**

Traceability is a formal system for identifying an item and following it through a distribution channel or supply

chain. The item could either be a single product (homogenous) or part of a heterogeneous product as an ingredient. Where it can still maintain its unique identity or lose it through mixing and blending. Ingredients in food lose their identity during processing. They can therefore only be identifiable at the point where they are mixed with other ingredient(s).

This identity must be well documented, and the new product shall also be identifiable at the onset as carrying individual ingredients with a unique identity. The unique identity is usually given in the form of batch or lot numbers which should be understood by the issuing authority/person/institution.

In coffee processing, therefore, traceability starts from the farm or plot from which cherries are harvested, preferably on the same day by the same set of persons.

Where different farms/plots are involved, cherries from each farm or plot should be given different batch numbers especially since they might have received separate agronomic practices. E.g., application of plant protection products (PPPs) on different days. This identity should be maintained so long as the products are within the care of the same person and sold or disposed of as such. They should be dried, de-hulled and bagged as such. Where an operator has a reason to put together cherries or beans from different sources (usually related), the new batch should have on record the sources of cherries that were put together from this new lot.

All incoming materials (raw materials and packaging materials) should be clearly identified with quantity, source and date of receipt. Ideally, each receipt must come with a waybill that should be filed. They should be kept differently and used in the production of different batches of products, either hulled or roasted beans.

Modern technology has helped to introduce QR codes to improve traceability.

### Hulling:

Cherries from different farms or suppliers should be dried, hulled and bagged separately and be clearly identify as different batches. Quantity should not matter as different batches can have different quantities.

A batch of hulled beans simply means a lot of beans received from a single farm or supplier, dried and processed under the same conditions.

That batch should be traceable to the machine and person who did the hulling, the drying process (bed) and the farm or supplier.

NOTE:

- Cherries from different farms or suppliers should constitute different batches and therefore should be dried and hulled separately.
- Cherries from the same farm or supplier that are dried on different beds should constitute different batches, whether they are processed the same day or not.
- Cherries from the same drying bed but hulled under different conditions such as date, machine operator or even same operator but different hours with a long break say morning and evening work or as a result of a power cut should be treated as different batches.

### Application of HACCP in coffee processing

HACCP is an acronym for Hazard Analysis (and) Critical Control Points. It is a Food Safety Management principle that assists food business managers in systematically identifying and managing potential food safety hazards that are likely to be associated with each process step including inputs till the product is out of the hands of the business operator. It is a risk-based approach to Food Safety Management and applicable from farm to folk, for big and complex as well as small and simple operations alike. In essence, the principle says for every process step:

- Identify all potential food safety hazards that may be associated with the incoming material of the process step;
- Analyse each hazard identified. Its source, characteristics, and risk profile (probability of occurrence and severity of disease incidence);

- Set critical limits to the acceptable presence (if any) of any hazard in the food;
- Determine and implement control measure to either eliminate or reduce the level of the hazard to acceptable levels that will not cause harm to consumers;
- Set stringent control measures and monitor criteria for processing steps where any loss of control over a hazard will result in the hazard continuing to exist in the food product (critical control points-CCP).

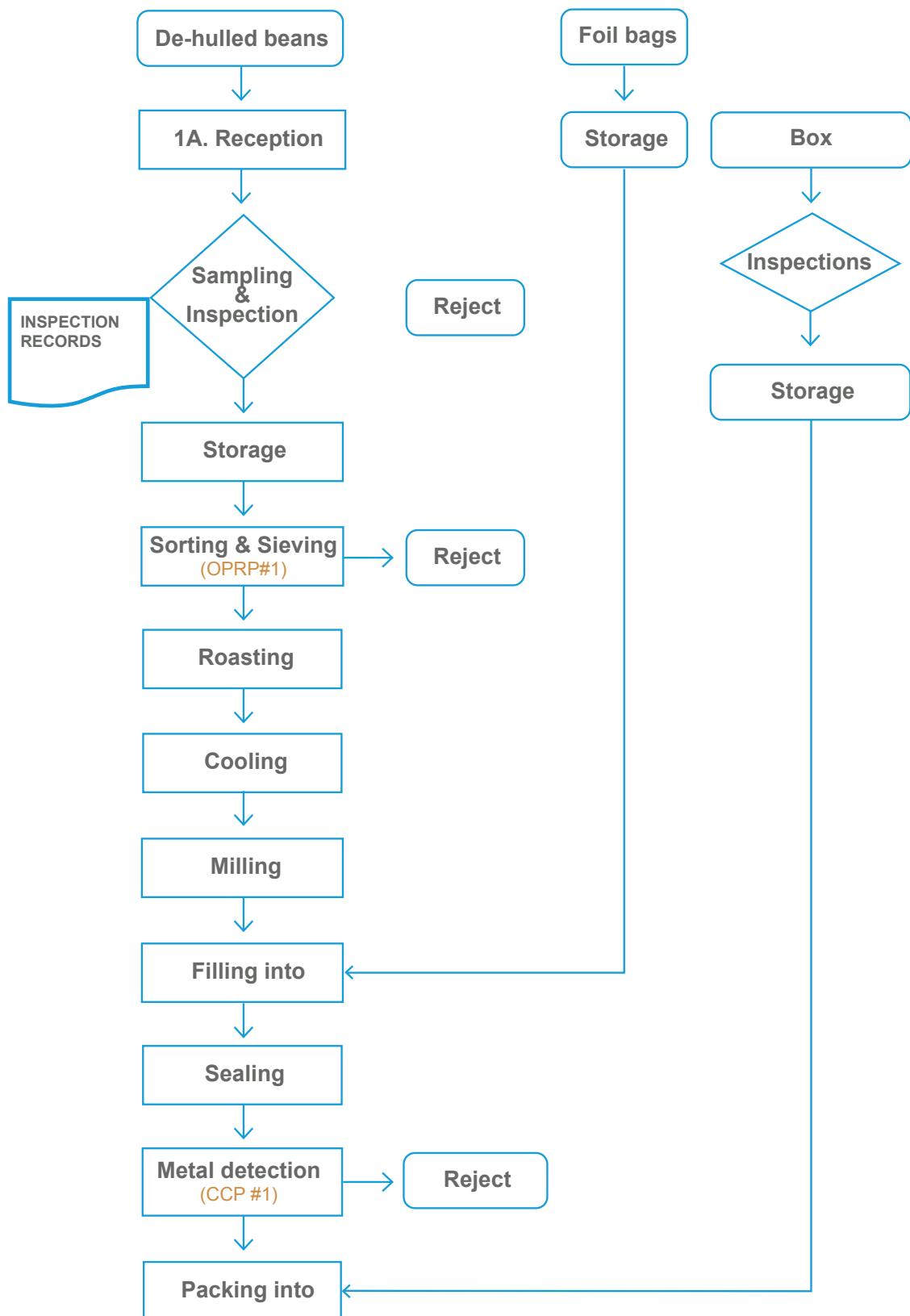
**Table 15 HACCP implementation involves 12 steps embedded with 7 principles**

Step	Activity	Principle
Step 1	Assembly a HACCP team <ul style="list-style-type: none"> <li>• A multidisciplinary team of staff who will be responsible for developing and implementing HACCP. It may include consultants if company does not have the needed internal human resource</li> <li>• Must be appropriate to the size and complexity of the operation</li> <li>• Should have the technical expertise and awareness of potential hazards</li> <li>• Must include management members with power to release resources</li> </ul>	
Step 2	Describe the product Detailed description of final product	
Step 3	Identify intended use State the intended use of the final product. Include at risk groups where necessary	
Step 4	Construct a process flow diagram A detailed systematic presentation of each processing step from the receipt of raw materials till final product leaves the hands of the company	
Step 5	Validate the flow diagram Walk through the processing flow with the flow diagram to ensure that it is an accurate reflection of the actual processes	
Step 6	Conduct a hazard analysis <ul style="list-style-type: none"> <li>• Identify potential hazards and source</li> <li>• Decide the risk level (significant and severity) of the hazard using a risk analysis matrix</li> <li>• Determine appropriate control measures</li> </ul>	Principle 1
Step 7	determine the Critical Control Point (CCPs) CCPs are processing steps where if significant hazards are not controlled, they persist in the food and possess health risk to the consumer	Principle 2
Step 8	Establish critical limits for each CCP <ul style="list-style-type: none"> <li>• Critical limits are maximum values set for control measures to ensure that the food is safe.</li> <li>• They must be measurable and unambiguous. E.g. Temperature, Water activity.</li> <li>• Breach of critical limits must lead to product quarantine for further decision</li> <li>• Corrective action must also be taken to get the system back to the target limit</li> </ul>	Principle 3
Step 9	Establish monitoring criteria at each CCP <ul style="list-style-type: none"> <li>• Determine critical limits and target levels to control the hazard.</li> <li>• Decide how, where, who and when critical limits are monitored</li> </ul>	Principle 4
Step 10	Establish corrective action(s) <ul style="list-style-type: none"> <li>What to do when a critical limit or target levels are missed</li> <li>c. What happens to the product (usually one of these: Rework, divert to other use or reject and destroy)</li> <li>d. How do we bring the system back under control (who is responsible, how to we agree it is achieved, authorisation to re-start)</li> </ul>	Principle 5
Step 11	Establish verification procedures <ul style="list-style-type: none"> <li>• Methods, procedures and tests in addition to the established monitoring system to demonstrate that the HACCP system is achieving desired results</li> <li>• It includes examination of monitoring records, audit of HACCP plan, product testing and analysis, etc</li> </ul>	Principle 6

Step 12	<p>Establish documentation and record keeping</p> <p>Documentation is key to demonstration of compliance and due diligence. Key documents include</p> <ul style="list-style-type: none"> <li>• Details of the HACCP team with scope of work</li> <li>• Product description with intended use</li> <li>• Process flow diagram</li> <li>• HACCP Pre-requisite programmes (GMP)</li> <li>• Hazard analysis chart</li> <li>• Control points determination and monitoring records</li> <li>• Verification, validation and audit records</li> <li>• Review of HACCP system,</li> </ul>	Principle 7
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### Hypothetical HACCP plan for coffee roasting

The HACCP plan presented below is a hypothetical plan and it is not based on the processes of any specific factory. It considers the general processes after hulling to the packing of milled coffee. This plan should therefore only serve as a guide and should be taken and adopted in any factory. Implementation of HACCP is factory specific and should be prepared based on the infrastructure, systems, and resources available per processing plant or factory. An HACCP plan should never be imported from one factory to another.

**Figure 8 Process flow diagram**

**Table 16 Hazard Analysis**

Process Step	HAZARD	HAZARD Class	Source of Hazard	Hazard assessment					Control Measuresz	Controlled By	Record
				Likelihood of occurrence	Severity of adverse health effect	RA= Likelihood X Severity	Significant hazard? (Yes/No)	Justification for hazard not being significant			
Green beans	Foreign materials	Physical	leaves, wooden pieces, dust, & stones	3	1	3	No	Most suppliers do not sort and grade beans	SQA. Inspection or Reject stock		Raw material receipt checklist
	Ink	Chemical	Ink used in labelling the sacks	1	1	1	No	It is possible that suppliers will use any ink to mark sacks	SQA		
	pesticide residue	Chemical	pesticide residue from farm activities	4	4	16	Yes	Most farmers educated on proper use of pesticides & weedicides	Training, Analysis		
	Mycotoxins	Chemical	Aflatoxin from moulds	3	4	12	Yes	Cherries could get mouldy through poor handling & drying	Training, Analysis of products		
Storage	dust	Physical	dust from the environment	1	3	3	No	Poor storage conditions could attract dust from outside	Implement good storage Practices		monitoring report
	microorganisms	Biological	moulds	2	4	8	No	Contamination from personnel and beans contact surfaces	Keep beans 12% moisture content		
Sieving and sorting	metal (ferrous and non-ferrous)	Physical	Rust and broken pieces from the sieve	3	4	12	Yes	The sieve can break into the product	constant inspection of sieve		sieve inspection report
	microorganisms	Biological	E.coli and Salmonella from workers	1	3	3	No	Limited chances of contamination by personnel and contact surfaces	Adherence to personal and environmental hygiene		staff health certificate
Roasting	Foreign materials	Physical	parts from roaster	1	3	3	No	Use of roasters constructed with food grade (rust resistant) materials	metal detection		Equipment maintenance report
Cooling	Foreign materials	Physical	dust and sand particles	1	3	3	No	Cooling area will be a restricted and controlled room	cleanliness		Environmental monitoring report
	Microorganisms	Biological	re-contamination with microorganisms from environment and contact surfaces	1	3	3	No	Room will be kept clean and dry to avoid condensation that will lead to moisture absorption	cleanliness and keep moisture content below 12%		
Milling	Foreign materials	Physical	wear and tear from machine parts	3	4	12	Yes	Possibility of wear and tear from mill teeth or hammer	metal detection		Equipment maintenance and metal detection report
	Lubricant	Chemical	grease	1	1	1	No	Only food grade lubricants will be used	GMP		
	biofilms from machine parts	Biological	salmonella, mould, E.coli	2	4	12	Yes	Poor cleaning of mill can lead to biofilms that will consistently leach into product	GMP		
Bagging into Foil pouch bag	Microorganisms	Biological	introduction of microorganisms into bag	1	3	3	No	Good practices will help eliminate such occurrence	GMP		
metal detection	Metal pieces	Physical	Missing metal contaminated products	2	5	10	Yes	Defective detector can result in missing of contaminated products	Legend testing		Detector monitoring record

**Table 17 CCP determination**

CONTROL MEASURE SELECTION AND CATEGORIZATION										
				Answer the following questions as applied in Codex Decision Tree:						
				Q1a: Do control preventive measure (s) exist at this step? YES: Go to Q2. NO: Go to Q1b						
				Q1b: Is control at this step necessary for safety? YES: Modify Step, Process or Product and Go to Q1a.NO: Step is not a CCP for that Hazard further step will control. Proceed to next identified hazard for the described process.						
				Q2: Is this step specifically designed to eliminate or reduce the likely occurrence of the hazard to an acceptable level? YES: Step is a CCP. NO: Go to Q3						
				Q3: Could contamination with identified hazard (s) occur in excess of acceptable level (s) or could these increase to unacceptable levels? YES: Go to Q4. NO: Step is not a CCP for that Hazard further step will control. Proceed to next identified hazard for the described process.						
				Q4: Will a subsequent step eliminate identified hazard (s) or reduce likelihood of occurrence to an acceptable level? YES: Step is not a CCP for that hazard further step will control. Proceed to next identified hazard for the described process.NO: Step is a CCP for the identified hazard						
Process Step	HAZARD	Hazard Class	Hazard SOURCE	Q1a	Q1b	Q2	Q3	Q4	CCP / PRP / OPRP	Control Measure
Sieving and sorting	metal (ferrous and non ferus)	Physical	Rust and broken pieces from the sieve	Yes		No	Yes	Yes	OPRP	Sieve monitoring. Installation of a metal detector
	Microorganisms	Biological	E.coli and Salmonella from workers	Yes		No	Yes	Yes	PRP	high level of personal hygiene
Roasting	Foreign materials	Physical	parts from roaster	Yes		No	Yes	Yes	PRP	Equipment monitoring and maintenance.
Cooling	Foreign materials	Physical	dust and sand particles	Yes		No	Yes	Yes	PRP	Environmental cleaning
	Microorganisms	Biological	re-contamination with microorganisms from environment and food contact surfaces	Yes		No	No		PRP	Cleaning and sanitisation of contact surfaces
Milling	Foreign materials	Physical	wear and tear from machine parts	Yes		No	Yes	yes	PRP	Equipment monitoring and maintenance.
	Lubricant	Chemical	grease	Yes		NO	No			use of only food grade lubricants. Observation of GMP
	biofilms from machine parts	Biological	salmonella, mould, E.coli	Yes		No	No		PRP	Equipment monitoring and maintenance.
Filling Foil bag	Microorganisms	Biological	introduction of microorganisms into foil pouch bags during filling	Yes		No	No		PRP	GMP
Metal Detection				Yes		Yes			CCP	Monitoring with legends (stainless steel, Ferrous and non-Ferrous)

**Table 18 CCP monitoring plan**

CCP N°	Step	Hazard description	Targets	Control Parameters	Critical Limit	Monitoring How, frequency, who?		
						Procedure (How)	Frequency	Responsible
CCP #1	Metal detection	Pieces of stainless steel, ferrous and non-ferrous materials from equipment and machine parts	Nil	legends	....microgram	Pass legends at the beginning and end of every production	anytime there is production	Quality Assurance Officer
Corrections	Corrective actions	Records	Verification (details in Verification Plan)			Validation methods and frequency		
Quarantine product between the last and current legend test. Get the detector fixed and recalibrated	1. Maintenance records 2. Validation records	1. Maintenance records 2. Validation records	Verify critical limits are being achieved through legend spot checks and detector calibration.			Annual calibration of metal detector		

**Table 19 CCP and OPRP verification plan**

CCP #/ OPRP #	Verification activity (e.g. of CCP monitoring or OPRP functioning, corrective actions)	Verification procedure (e.g. methods or procedures to use, observations to be made or measurements to be taken, actions if there is a deviation or follow-up)	Frequency (how often is the task to be performed)	Responsibility (who is responsible for the task)	Records (which records should be used)
CCP #1	Verify critical limits are being achieved by passing of legends during production, calibration of detector, interview operator, review of records, spot checks	Pass all legends (ferrous, non-ferrous, and stainless steel) under the detector and ensure that these are detected.	During Production	Quality Assurance Manager	Metal detector record sheet
oPRP # 1	Verification of the integrity of the sieve. Any evidence of broken part should lead to product quarantine and investigated	Physical inspection with eyes and rubbing of figures over the sieve surface	During Production	Quality Assurance Manager	Sieve inspection record

## Chapter 4

# Product Development in Coffee Processing

Product development is crucial in coffee processing, and this can be achieved in several ways. These include the use of by-products from coffee processing, coffee blending, product fortification and recipe formulation, decaffeination, and packaging of roasted coffee beans.



### By-products from coffee processing

Harvesting and processing of coffee results in the generation of by-products that are often discarded. The by-products from coffee processing include those derived from post-harvest processing, coffee roasting, and coffee consumption and can be considered as potential functional ingredients for the food industry. These include husks, skin and pulp, immature/defective beans, parchment, silver skin, and spent coffee.

#### Coffee husks/skin and pulp

Coffee husks are the main solid residues obtained during coffee dry processing and are composed of the dried skin, the pulp, the mucilage, and the parchment, all together in a single fraction. Coffee skin and pulp are obtained from wet processing and have a similar composition to that of the husks. Coffee husks and pulp can be used for

- Extraction of caffeine and polyphenols
- Fertilizers
- Composting or vermicomposting
- Biosorbents
- Production of value-added products, such as enzymes, organic acids, flavour, and aroma compounds
- Animal feed, biofertilizer, and as a substrate to produce edible mushrooms. However, the phytotoxic compounds and antinutritional factors in the husks and pulp needs to be degraded, or at least reduce to a plausibly safe level.

#### Immature and defective coffee beans

Immature and defective coffee beans are obtained during harvesting and pre-processing operations. Immature

beans usually result from immature fruits while defective beans comprise black, sour, brown, immature, bored, or insect-damaged and broken beans. Uses of these low-grade beans include:

- Extraction of oil
- Extraction of bioactive compounds, such as chlorogenic acid and caffeine

Both the oil and bioactive compounds have potential applications in the food and pharmaceutical industries.

### Coffee silverskin

Coffee silverskin is a thin layer that is directly in contact with the coffee bean and is detached during roasting. It is the main by-product of coffee roasting. Uses of the silverskin include:

- Fuel (such as firelighters)
- Composting and soil fertilization
- Used as a dietary fiber-rich ingredient
- As a functional ingredient in food fortification due to antioxidant properties
- Used as a cosmetic active ingredient

### Spent coffee

Spent coffee is the main by-product of the coffee brewing process. They are obtained by both domestic brew preparation (at coffee shops, restaurants, homes) or during the industrial preparation of instant coffee. Potential uses of spent coffee grounds include:

- Extraction of bioactive compounds (Caffeine, Caffeoylquinic acids, Feruloylquinic acids)
- Production of fuel for industrial boilers
- Animal feed
- Substrate for fungal growth
- Adsorbent for the removal of heavy metals
- Preparation of a distilled beverage with coffee aroma

### Coffee blending

Coffee blending can be used as a simple but important tool in product development. This involves combining or mixing roasted coffee beans from different origins/regions, farms, and types to obtain 'specialty' products in terms of aroma, flavour, and taste. The proportion of the blend depends on the processor, market, attributes of the individual coffee, and the desired end-product and can include blending different types of coffee (Arabica and Robusta) to obtain unique and specialty products.

### Product fortification and recipe formulation

This involves adding functional food ingredients to the roasted ground coffee to improve the overall nutritional quality of coffee. Examples include the addition of local spices and herbs, beetroot powder, etc., to roasted ground coffee. It also involves the addition of roasted ground coffee to other foods (as flavour) to enhance the flavour quality. Examples include the addition of roasted ground coffee to chocolate, cake, and candies.

### Decaffeination

Decaffeination can be used to produce new coffee products. It involves the removal of caffeine from the green coffee beans before roasting. The process of decaffeination involves:

- Immersing the green coffee beans in water or steam so the caffeine can be extracted
- Extracting the caffeine from the beans using water, a solvent, or activated carbon
- Drying the decaffeinated beans back to their normal moisture level.

## Packaging

Packaging of roasted coffee beans (whole or ground) is another form of product development. New, attractive, and convenient packaging (paper pouch, polypropylene bags, and steep coffee bags) can be used to produce different ranges of coffee for the market.

## Appendices

### Appendix I Samples policy statements

#### AYA PLC PORTOFOLIO

##### Food Safety Policy

AYA PLC is a fruit processing company involved in the packaging of fresh mangoes mainly for export. Management of AYA PLC is committed to delivering to its customers and consumers; safe, consistent, and wholesome fresh products by implementing codex HACCP requirements.

The company complies with relevant statutory and regulatory requirements mandated by clients and all other relevant legislations, codes of practices and approved guidelines mandated for its operations in Ghana and outside Ghana.

Management is committed to the provision of adequate resources to ensure the implementation and maintenance of AYA PLC Food Safety Management System.

Management shall ensure relevant information on the Food Safety Management System is communicated to all stakeholders of the company and that personnel are aware of the policy and its implementation in all departments of the company.

The company shall ensure this policy is reported, reviewed and updated annually, and in line with customer requirements for continued suitability.

Signed.....

Managing Director

#### ENVIRONMENTAL POLICY

##### KSC LTD

KSC Ltd is conscious of the impact of its operations on the environment and has measures to mitigate any adverse effects farm activities might have on the environment. Our fields size is small; however, special efforts shall be made to ensure pesticide usage does not harm flora and fauna. We shall also strive to conserve the biodiversity of the farm environment. Consequently, unproductive sites where applicable, shall be managed as conservation areas for fauna and flora. Members shall be encouraged to conserve a few indigenous trees or plant trees to provide shade and serve as roosting sites for birds.

Other environmental protection activities include:

- avoidance of bush burning except where to control mealybugs and ants
- avoidance of pollution of water bodies through safe disposal of pesticides
- respect to the Riparian by not farming too close to water bodies (at least 100m away from river body).

Signed .....

General Manager

## Appendix II Sample SOPs

DOCUMENT TITLE:	INTRODUCTION	REASON FOR REVIEW:
SERIAL NUMBER:	PREPARED BY:	DATE PREPARED:
SOP NUMBER:	REVIEWED BY:	DATE REVIEWED:
STANDARD:	APPROVED BY:	DATE APPROVED:

### REPORTING TO WORK

- Wash your hands with soap under running water at the security gate
- Change clothes into working gear in the changing room
- Wear nose mask and hair net (hair cover)
- Remove bracelets, watch, earrings and other jewelleries
- Change footwear and wear working sandals
- Wash your hands again with soap under running water in front of the processing hall

DOCUMENT TITLE:	INTRODUCTION	REASON FOR REVIEW:
SERIAL NUMBER:	PREPARED BY:	DATE PREPARED:
SOP NUMBER:	REVIEWED BY:	DATE REVIEWED:
STANDARD:	APPROVED BY:	DATE APPROVED:

### RAW MATERIAL RECEPTION

- Clean raw material reception area thoroughly
- Check quality of green beans prior to reception
- Record weight, date, and source of raw materials
- Label all raw materials received
- Ensure green beans are stored in jute sacks and on raised platforms
- Store green beans from different farms, agents and harvests separately

DOCUMENT TITLE:	INTRODUCTION	REASON FOR REVIEW:
SERIAL NUMBER:	PREPARED BY:	DATE PREPARED:
SOP NUMBER:	REVIEWED BY:	DATE REVIEWED:
STANDARD:	APPROVED BY:	DATE APPROVED:

### SORTING

- Ensure the container or the wooden sifter box for sorting is clean before pouring the green in it

- Pour the green beans into the container or wooden sifter box
- Remove black, insect infested and un-hulled beans
- Sort the beans by size and weight as well as colour

DOCUMENT TITLE:	INTRODUCTION	REASON FOR REVIEW:
SERIAL NUMBER:	PREPARED BY:	DATE PREPARED:
SOP NUMBER:	REVIEWED BY:	DATE REVIEWED:
STANDARD:	APPROVED BY:	DATE APPROVED:

## ROASTING

- Clean the roaster before use
- Set fire to the roaster
- Set the time and temperature to ... minutes and .....degrees Celsius
- Pour the green beans into the roaster
- Roast until it is properly roasted
- Allow to cool and collect roasted beans in clean container

DOCUMENT TITLE:	INTRODUCTION	REASON FOR REVIEW:
SERIAL NUMBER:	PREPARED BY:	DATE PREPARED:
SOP NUMBER:	REVIEWED BY:	DATE REVIEWED:
STANDARD:	APPROVED BY:	DATE APPROVED:

## Milling

- Clean the mill before use
- Pour the roasted coffee beans into the hopper of the mill
- Place a clean container beneath the outlet of the mill to collect the milled coffee
- Turn on the mill and mill the beans to required particle size
- Clean the mill after use

DOCUMENT TITLE:	INTRODUCTION	REASON FOR REVIEW:
SERIAL NUMBER:	PREPARED BY:	DATE PREPARED:
SOP NUMBER:	REVIEWED BY:	DATE REVIEWED:
STANDARD:	APPROVED BY:	DATE APPROVED:

## PACKAGING

- Wash hands with soap under running water before packaging
- Wear clean nose mask, hair cover and hand gloves
- Clean containers, cups, ladles, weighing scale before use
- Fetch the roasted coffee (milled or un-milled) into clean packaging material
- Weigh to ensure weight is the same as required by the market
- Seal packed coffee tightly

### Appendix III some GMP posters







International  
Trade  
Centre

ALLIANCES  
FOR ACTION