

PROCESSING OF COFFEE

INTRODUCTION

Everyday's life begins with a cup of Coffee is defined as a beverage made by percolation method or collecting decoction from the roasted and powdered seeds of coffee. Coffee was first known to be used in 15th century in Ethiopia and widely liked and consumed commodity all over the world. The leaves, which also contain caffeine, were munched at first. At some point, the fruits were used for coffee making. "Coffee brewing" was first introduced by the Arabs, thereby deriving its name from Arabic. Coffee is presently cultivated in numerous countries thereby providing employment to a large population in the world. Coffee ranges from black, light to dark brown, white, beige and can be consumed in hot or cold condition.

1. PRODUCTION

The world coffee demand and supply depends on the prices on the world market. Next to oil, coffee stands second in world trade. Coffee is cultivated in 60 different countries. Brazil is the leading producer of coffee in the world. Brazil has produced more than 40 percent of that total global coffee production. Vietnam's production is forecast at a record up to 13 percent. India stands sixth in global coffee production of 3 percent.

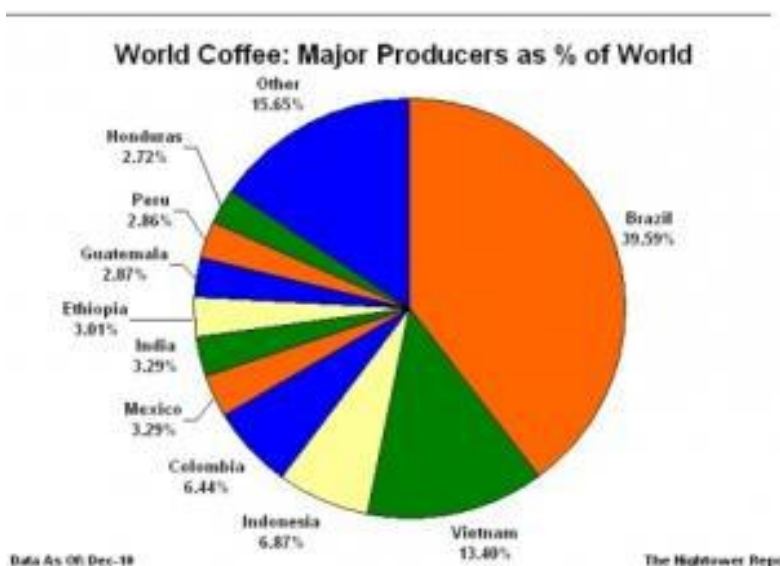


Fig.1. Major coffee producers of the world

Karnataka is the leading producer of coffee in India accounting to 53 percent followed by Kerala 28 percent and Tamil Nadu 11 percent. In India coffee, coffee is grown in shade for purest varieties.

2 Varieties:

Among the nearly 60 varieties of coffee, Arabica, Robusta and Liberica are three major varieties grown worldwide.

2.1 Arabica (*Coffea arabica*)

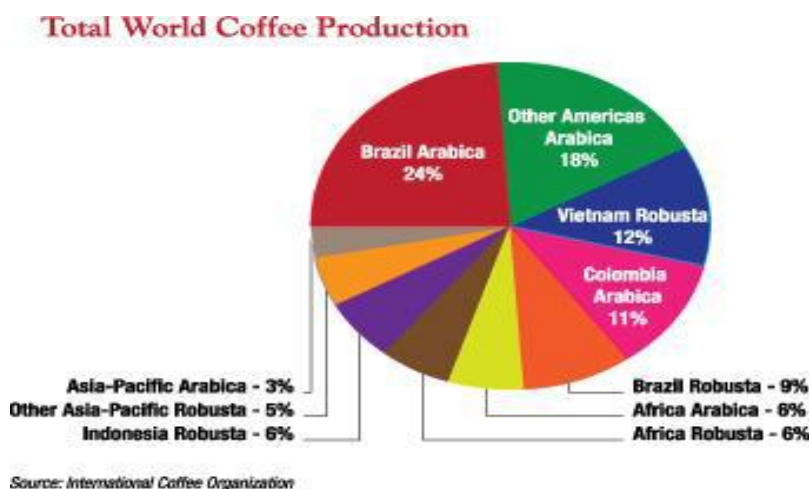
The Arabica variety coffee is highly demanded due to its superior flavour and aroma. Arabica is grown in low temperature climatic conditions at nearly 15-20°C. *Coffea arabica* contributes to about 90% of world's trade in coffee.

2.2 Robusta (*Coffea canephora*)

Robusta varieties are grown in hot climates more than 20°C. Owing to their higher soluble solid content they are much preferred for instant coffee production.

2.3 Liberica (*Coffea liberica*)

These varieties of trees grow in both extreme climates. This yields bitter tasting coffee.



(<http://www.futuresindustry.org>)

Fig.2. World coffee production by variety

Arabica, the mild aromatic coffee makes up more than 60 percent of total world coffee production, whereas *Coffea canephora* contributes to 9 percent and *C. liberica* represents 1 percent only.

3. Harvesting & Processing:

Coffee belongs to the Rubiaceae family. The coffee tree is a shrub, with a total life of about 70 years, yielding commercial profitability from the fifth year.



FIG. 3 THE COFFEE TREE



FIG.4 THE COFFEE CHERRY

3.1 The cherry

The coffee fruit is termed as “The cherry”. Cherry ripening takes several months with subsequent color change in every stage. The cherries take several months to ripen, turning yellow to red and finally black. The harvest index for the cherries is when they turn reddish in color. The exocarp is the outer red skin within which the pulpy mesocarp is present followed by the endocarp, beneath which the two beans are present with the flat surfaces facing each other. The seed coat termed as “silver skin” is another thinner membrane that covers the seed coat. Usually there are two coffee beans and rarely one berry termed as pea berry is present. After 8 to 9 months of the flowering stage, the berries are ready for picking. A vital part in harvesting is to pick only the red and firm ripe berries. The over-ripened garnet-red, violet or black results in the final product an unpleasant flavor and taste.

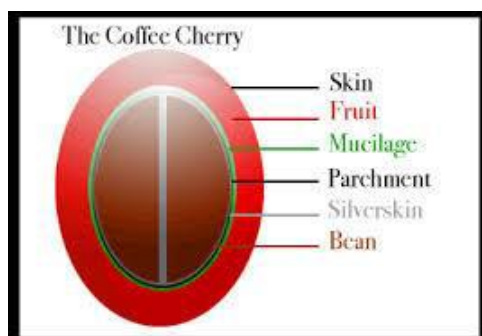


Fig.5. The coffee cherry

3.2 Harvesting

3.2.1. Four methods of coffee picking are practiced throughout the world:

- **Stripping** is a manual method where the entire branch contents are stripped and then separating the ripe cherries alone. This method produces poor results.

- The second method employs a comb that is easily flexible causing only the ripe cherries to fall down.
- Third method is the mechanical method which makes use of mechanical vibrators that are rigidly clamped to the tree, that gives a vibration to make the ripe fruit to separate and is thus collected.
- The widely followed method all over the world is the handpicking method. This is the most expensive method due to the intensive labor, but results in good quality coffee.

3.3. Coffee Cherry Processing

The removed coffee beans are subjected to drying before they are roasted. Generally, the two methods that are practiced in drying of coffee beans are the dry and the wet method. Green coffee is the term referring to unroasted coffee beans.



Fig.6. Ripe coffee cherry

3.3.1. Dry Method

The dry method is the age old and simple method practiced in coffee processing, which requires little machinery. The undried coffee cherry is dried in this method and depends on various factors like plantation size and quality of the product. The processing steps involved in dry method of coffee processing are cleaning, drying and hulling, as described below.

3.3.1.1 Cleaning

The harvested cherries are subjected to sorting and cleaning, for the separation of dockage. Winnowing could be done manually. The ripe cherries are separated by applying the flotation technique in flowing water.

3.3.1.2. Drying

The coffee cherries are sun dried on waist height wire mesh tables. During drying, they are turned to ensure uniform drying for 4 weeks to the optimum 11% moisture content. Machine drying is used on larger plantations to speed up the process with preliminary sun drying for a few

days. The final quality of coffee greatly depends on the drying operation. Improperly dried beans are prone to rapid deterioration due to fungal and bacterial infestation.

3.3.1.3 Hulling

After drying the cherries are kept in bulk in storage silos or in jute bags until they are subjected to hulling to separate the outer layers.

The dry method of coffee processing is majorly used for the Arabica coffee variety

3.3.2. Wet Method

The wet method uses washing equipments and water. This method yields better qualities coffee beans rendering a high quality green coffee. Similar to the dry method the first step of sorting and cleaning of the coffee is done by subjecting the cherries to washing in flowing water followed by screen separation.

3.4 Pulping

Pulping is the process of removing the outer skin called as the exocarp from the white fleshy pulp termed as mesocarp that separates the pulp and beans from the sorted and cleaned cherries. This is carried out immediately after harvesting to prevent quality deterioration in the final product. The pulping machine separates the flesh and the skin of the fruit from the beans, by rubbing the surface of the coffee cherry between two plates.

3.4.1 Types of Pulpers

The two types of pulpers widely used are:

- Drum pulpers and
- Disc pulpers

3.4.1.1. Drum pulpers

This consists of a rotating drum with a slotted surface and a plate that is movable between which the coffee cherries are pulped to remove the pulp and the beans separated. This can be operated manually or by attaching to a motor.



Fig.7. Drum pulper

3.4.1.2. Disc pulpers

A rough surface disc is used to remove the pulp from the cherries. Further separation is done in vibrating screens that separate the unpulped or imperfectly pulped cherries. The pulped beans are further passed in water troughs for a separation. In order to remove any adhering sticky residual pulp that may invade microbes, the wet and pulped beans are stored in tanks meant for fermentation to break down the mucilage by enzymes and further washing in 2 to 3 days, determined by factors like temperature, thickness of skin and enzymes. When the end of the fermentation is reached the beans is free of its slithery nature and attains a rough texture.

3.5. Final Washing

The coffee beans are subjected to complete washing after fermentation. The wet coffee comprises of nearly 57% moisture at this stage.

3.6. Drying

The drying of coffee beans should be done slowly to nearly 10% moisture content to prevent cracking. Immediate drying prevents off flavors in coffee. The beans are dried to decrease the moisture to an optimum of 11 percent, by the following methods

- Sun drying
- Mechanical drying
- Combination of both methods

3.6.1. Sun drying

Vast areas made of cement and bricks or on tables made of netted wire in depth of 2 to 10 cm, and turned uniformly for drying. It is continued for 8 to 10 days depending on the climatic conditions.

3.6.2. Mechanical drying

Hot-air driers are used under controlled conditions to hasten the drying process to obtain good and easy drying to yield best quality of coffee. This wet-processed coffee termed as parchment coffee is stored or passes on to hulling. The dried cherry from the dry process or the parchment coffee from the wet process is allowed to rest for 8 hours in a ventilated area. It is then hulled to separate the pericarp, by a pestle and mortar or in a motorized huller. The mechanically operated hullers comprise a steel screw with an increasing pitch towards the outlet which removes the pericarp.

3.8 Cleaning

Winnowing is the removal of the hull from the coffee bean. The hulled coffee is then passed through a sequence of operations like cleaning, screening, sorting and grading. Electronic sorting machines are utilized for the separation of the broken and damaged beans and stored in jute bags in a cool and dry area.

3.9 Grading

Cured coffee is graded according to color, odour, size, shape and density.

- Color grading: Black, greyish beans, foxy red beans, white, opalescent, and glassy beans, blotchy or spotted beans are rejected in a colour sorter.
- Based on aroma, coffee beans termed “stinkers” that release a putrid odour and also rancid or acid beans, musty beans and rio flavoured beans are removed since they produce undrinkable coffee.
- Other abnormalities including droughted beans, broken and crushed beans, pitted beans, elephant beans and other foreign matter and debris are eliminated in the grading process.
- The different grades of coffee are:
 - Pea berry which are oval shaped beans
 - or A grade beans that are first size in flats- bold, heavy and well formed
 - B Grade rendering slightly smaller than O or A
 - C Grade that are slightly smaller than B and
 - Triage Grade having pale, discoloured, black spotted beans.

4. Processed coffee products

The commercially processed coffee products are:

- Coffee powder
- Instant coffee
- Decaffeinated coffee

4.1. Coffee powder

4.1.1. Roasting

Roasting plays a significant role in the final flavor of coffee. Roasting is a time temperature dependant process which is assessed visually, when a thin white line existing on either sides of the bean turns brown. Coffee beans are roasted in a saucepan in sand at 200 degrees with continuous stirring. Mechanical roasters are also employed for bulk production.

4.1.2. Grinding

Manual grinders and motorized mechanical grinders are the two types of grinders that are employed in the production of coffee powder.

4.1.3. Manual grinders

Manual grinding mills that were used to grind coffee are replaced by a treadle with two wheels or a cycle that is attached to the grinding wheel, on which a person sits and grinds to produce nearly 30kg per day. A series of these grinders may be used to grind up to 100kg/day.

4.1.4. Motorised grinder

Motorised grinding mills are applicable for large scale manufacturing. Plates in horizontal or vertical directions or hammer mills with adjusted mill opening according to the desired fineness of the end product are suitable for grinding coffee. The ground coffee is packed and stored in a dry, cool place.

A study on the influence of roasting and brewing methods on anti nutritional diterpenes, in coffee brew by analyzing for cafestol and kahweol profiles by using HPLC. This study revealed that roasting temperatures and roasting times had significant influence on diterpenes profiles in roasted beans.

4.2. Instant coffee

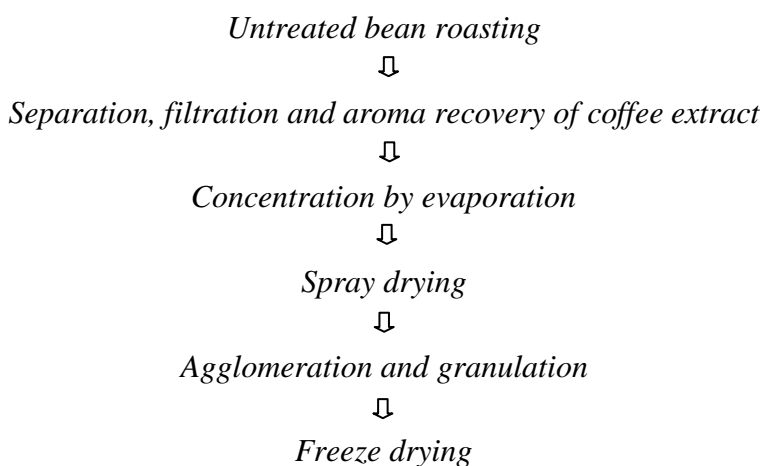


Fig. Preparation of instant coffee

The extraction of soluble coffee solids and volatile compounds from roasted and ground coffee powder, followed by drying into a powder or granules is done for Instant coffee production.

4.2.1. Pre stripping

Over 700 volatile compounds are separated for the manufacture of dissoluble coffee solids, by passing high pressure steam through a layer of ground coffee powder. The condensate with the extracts with volatile compounds and steam are condensed by using a condenser.

4.2.2. Extraction of coffee solids

Water is used as the solvent to extract the coffee solids. Extraction is proceeded at a temperature of 175°C.

There are three methods of extraction commonly practiced.

4.2.3. Percolation calandrias

This is the most commonly used method of coffee solid extraction where the roast and ground coffee is contained in a continuous series of 5-8 vessels at 170°C to 175°C. After the complete extraction of soluble coffee solids by passing hot water in each vessel, the emptied vessel is replaced with a new vessel until the solution reaches 15-25% w/w solubles.

4.2.4. Countercurrent system

This system comprises of an inclined cylindrical vessel into which coffee is fed continuously into the bottom and is moved upwards and downwards by two helical screws with a speed of 10-22 revolutions per hour. From the inlet at the top hot water is passed from the top and the outlet is at the bottom from which extracted solids are received at the bottom, at a vessel pressure of 180°C.

4.2.5. Slurry extraction

Centrifugation technique is used to separate the coffee and water after agitation in a tank.

4.2.6. Drying

The three different methods of drying the slurry are by using spray drier or a freeze drier or a drum drier.

4.2.6.1. Spray drying

The concentrated coffee solutions are uniformly 'atomised' in a centrifugal atomizer, to form droplets of 10-200 micrometers diameter at a temperature of 150-300°C. This is done in a large drying chamber, by spraying the liquid in hot air in the middle of a rotating bowl, producing droplets with diameters of 50-60 micrometers that are dried very rapidly within 10 seconds. A screw conveyor is used to remove the dry powder. These type of driers are very costly due to the high energy costs.

4.2.6.2. Freeze drying

Freeze drying follows the principle of sublimation. The material is subjected to a pressure of 610 Pa and heated to cause sublimation. A vacuum pump is used to remove the vapour and it is made to condense on refrigeration coils. The final drying is the step of evaporative drying at a very low pressure. Coffee is to be frozen as foam by bubbling gas in the liquid. This is a very expensive method.

4.2.6.3. Drum drying

This is a rarely employed method in which the liquid extracts that are being dried come into direct contact with a heated cylindrical surface.

4.3. Decaffeinated coffee

Though coffee renders a stimulating effect a part of the population also prefer decaffeinated coffee. The steps in preparation of this type of coffee are:

Decaffeination or simply **decaf** is the removal of caffeine from coffee beans; Decaffeinated coffee contains approximately 1–20% of the original caffeine content. Unroasted beans are encountered with steam and dipped with a solvent that completely extracts the caffeine while leaving other constituents largely unaffected. The process is continued for several times till nearly 97% of caffeine is separated according to the International Standard. Over 400 volatile components present in coffee and it is difficult to remove the caffeine alone without affecting other components to give decaffeinated coffee with good flavour.

5. Packaging

Packaging of coffee is done in polypropylene packages to prevent the loss of aromatic components of coffee.

6. Storage

A modern method of storage like Modified Atmospheric Storage may be recommended for storage. Generally storage at low temperature and low humidity in a clean environment is suitable. The recommended storage area for coffee is a shady, dry place.

7. Analyzing the Research and Development in Coffee:

According to the **U.S. Specialty Coffee Consumption Report 2014**, Annual Drinking Trends Study, the key takeaways in current coffee consumption trend worldwide are reported as:

- Consumers prefer more and better tasting coffee worldwide;
- The market share of specialty cups exceeds non-specialty coffee over 51%
- Overall trending suggests sustained momentum for specialty coffee growth in the last five years giving rise to a growing trend;
- There is a Notable weekly consumption shift towards specialty varieties than the traditional varieties of coffee.

Although multiple and fancy blends of coffee are constantly being introduced in the market there are still a plethora of unexplored varieties to come in the future.

8. Summary

1. Brazil is the leading producer of coffee in the world and in India Karnataka stands first in the production of coffee.
2. The worldwide varieties of coffee are Arabica, Robusta and Liberica.
3. Ripened red cherries are harvested by stripping, mechanical harvesting, combing and hand picking.
4. The pulping operation includes a dry method and wet method where sun drying is widely practiced in dry method and in wet method washed cherries are fermented and dried to give parchment coffee.

5. Cleaning, hulling and grading steps entirely denoted as curing of coffee is done and this is packed in jute bags or transported for further processing.
6. The major products from coffee are ground coffee, instant coffee and decaffeinated coffee among which Instant coffee is widely preferred.
7. The **U.S. Specialty Coffee Consumption Report** 2014 states that the market share for specialty coffee is at a higher growth rate and consumption pattern has made a tremendous shift towards specialty coffee.