A COMPREHENSIVE REVIEW OF COFFEE

Abinaya R, Abirami V, Kilimozhi D, Anton Smith A*

Department of Pharmacy, Faculty of Engineering and Technology, Annamalai University, Annamalai Nagar – 608002, Tamil Nadu, India.

Abstract:

Coffee is a genus of flowering plants in the family Rubiaceae. The coffee plant ranks as one of the most valuable and widely traded commodity crops and is an important export product to several countries. There are over 120 species of coffee varieties available, among them, Arabica and Robusta are widely used. The advantages of Coffee are lower type 2 diabetes, heart disease, liver and endometrial cancers, Parkinson's disease, and depression. The limitations include irritation in the stomach, increased anxiety, and disrupted sleep. The coffees are adulterated with chicory to reduce the bitter taste. This review is used to learn about the History, Classification, Chemical Composition, Advantages and Limitations of coffee.

1. INTRODUCTION

The renowned beverage we enjoy worldwide originates from the seeds found within the fruits of trees and shrubs grown naturally in the shaded African forests, including Madagascar and Mauritius, as well as in tropical regions like equatorial Africa, Java, Sumatra, and various islands of the Dutch East Indies, West Indies, the Pacific, Mexico, Central, and South America. These seeds, commonly referred to as green coffee beans, are cultivated from the coffee tree, a member of the Angiosperm subkingdom within the botanical family Rubiaceae, which boasts around 500 genera and over 6000 species. Within the Rubiaceae family, *Coffea Arabica* and *Coffea canephora* are two commonly cultivated species globally. Arabica seeds contribute to over 60% of the world's coffee production, while Robusta accounts for 40-45% (Andriana & Thiago, 2015).

2. COFFEE PROPAGATION

The history of coffee cultivation is intricately intertwined with the early history of drinking, but we will focus solely on the origins and development of the coffee plant's cultivation. The coffee plant is native to Abyssinia (Ethiopia) and possibly Arabia, from where it spread throughout the tropical regions. The first reliable record of the plant's properties and uses is attributed to an Arabian physician in the late ninth century A.D. It is plausible to assume that the plant grew wild in Abyssinia and perhaps Arabia before that time. Ludolphus suggests that the Abyssinians migrated from Arabia to Ethiopia in ancient times, and they may have brought the coffee tree with them. However, the Arabians deserve credit for discovering and promoting the propagation of the plant, even if they encountered it in Abyssinia and transported it to Yemen. Some experts believe that coffee cultivation in Yemen can be traced back to 575 A.D. When the Persian invasion ended the Ethiopian reign of Negus Caleb, who conquered the region in 525, the discovery of the beverage likely led to the cultivation of the plant in Abyssinia and Arabia (William, 1922; Mark, 2019).

The introduction of coffee cultivation to southern India is credited to Baba Buden, a Muslim pilgrim, who supposedly planted coffee seeds as early as 1600, although other sources suggest the year 1695. According to Indian tradition, Baba Budan planted the seeds near his hut in Chickmaglur, located in the mountains of Mysore. It was observed the descendants of these original plants growing under the shade of ancient jungle trees. The majority of the plants cultivated by the natives of Kurg and Mysore seem to have originated from the coffee seeds brought by Baba Budan. It wasn't until 1840 that the English commenced coffee cultivation in India. Today, coffee plantations extend from the northernmost part of Mysore to Tuticorin. Coffee cultivation spread to various regions, including the Dutch colonies, Western Europe, France, and Holland, Germany.

2.1 Dutch:

In the late 16th century, German, Italian, and Dutch botanists and travelers brought back valuable information about the new coffee plant and beverage from the Levant. In 1614, Dutch traders started exploring the possibilities of coffee cultivation and trading. Two years later, they successfully transported a coffee plant from Mocha to Holland. In 1658, the Dutch began cultivating coffee in Ceylon (Sri Lanka), although it is believed that the Arabs had brought the plant to the island before 1505. An unsuccessful attempt to cultivate coffee on European soil was made in Dijon, France, in 1670. In 1696, the first coffee plant was introduced to Java by Adrian van Omen, shipped from Malabar, India, at the instigation of Nicolas Witsen. The Dutch took the lead in propagating the coffee plant, extending cultivation to various islands of the Dutch East Indies.

By 1706, the first sample of Java coffee and a coffee plant grown in Java reached the Amsterdam botanical gardens. While the Dutch expanded coffee cultivation to Sumatra, the Celebes, Timor, Bali, and other islands, the French were also attempting to introduce coffee cultivation in their colonies. In 1714, a young and robust coffee plant was sent to Louis XIV at the Château of Marly from the Amsterdam botanical garden. Gabriel Mathieu de Clieu, a naval officer at Martinique, successfully transported a coffee plant from the botanical garden to the Antilles, leading to the first coffee harvest in 1726. Coffee cultivation was introduced into Haiti, Santo Domingo, and the Isle of Bourbon (Réunion) in the early 18th century. The Dutch brought coffee cultivation to Surinam, and the English introduced it to Jamaica in the 18th century.

Coffee cultivation spread to various regions throughout the 18th and 19th centuries. In 1740, Spanish missionaries introduced coffee cultivation to the Philippines from Java. In 1748, coffee was introduced into Cuba, and in 1750, the Dutch extended cultivation to the Celebes. Coffee was introduced into Guatemala around 1750-1760, and intensive cultivation in Brazil began in 1752. Coffee cultivation started in Puerto Rico in about 1755, and in 1779, it was introduced into Costa Rica from Cuba. Mexico began coffee cultivation in 1790, and intensive cultivation in the state of Veracruz started in 1817. In 1825, coffee cultivation began in Hawaii, and in 1840, the English began cultivating coffee in India. Coffee cultivation was introduced to Salvador in 1852, British Central Africa in 1878, and British East Africa in 1901. In 1887, the French introduced coffee cultivation in Tonkin, Indo-China, and in 1896, coffee growing in Queensland, Australia, met with some success. (William, 1922; Mark, 2019).

2.2 Western Europe:

Venetian traders introduced coffee to Europe in 1615, and the first European mention of coffee was made by Leonhard Rauwolf in 1573. The first cup of coffee in Europe was enjoyed in Venice in the late 16th century. The first coffee berries were imported by Mocegio, a trader known as the "pevere." The exact date of the first coffee house in Italy is uncertain, but it is believed to have opened around 1645. The famous Caffè Florian was established in Venice in 1720. Coffee houses flourished in Italy during the late 17th and early 18th centuries. Italy is credited with introducing the concept of the coffee house to the Western world, although the French and Austrians made significant improvements. In Venice, almost every shop on the Piazza di San Marco became a caffe (William, 1922; Mark, 2019).

2.3 France:

French travelers like Tavernier, Thevenot, and Bernier played a crucial role in introducing coffee to France. Jean la Roque's voyage to Arabia in 1708-13, and his father's importation of coffee in 1644, also contributed to the French fascination with the beverage. In the 1660s, merchants from Marseilles brought coffee beans from the Levant, leading to its widespread use in the region. In 1671, coffee houses opened near the exchange in Marseilles, attracting merchants and travelers. In 1669, Soliman Aga, the Turkish ambassador, introduced Turkish-style coffee to Paris, and two years later, Pascal, an

Armenian, opened the first coffee booth at the fair of St. Germain, marking the beginning of coffee houses in Paris. The first licensed coffee merchant in France was Damame Francois, who obtained the privilege in 1692 (William, 1922; Mark, 2019).

2.4 Holland:

In 1616, Pieter Van dan Broeck brought the first coffee from Mocha to Holland. In 1640, a Dutch merchant named Wurffbain offered the first commercial shipment of Mocha coffee for sale in Amsterdam. The Dutch began coffee cultivation in Ceylon (Sri Lanka) after driving out the Portuguese in 1658, although the plant had been introduced by the Arabs before the Portuguese invasion. It was not until 1690 that the Dutch undertook systematic cultivation of coffee in Ceylon. Regular imports of coffee from Mocha to Amsterdam started in 1663, and later supplies arrived from the Malabar Coast. Pasqua Rosee, who introduced coffee houses to London in 1652, also made coffee popular as a beverage in Holland in 1664. The first coffee house in The Hague opened on Korten Voorhout. In 1706, the first Java coffee from Batavia arrived in Amsterdam, including a shipment of 894 pounds from the Jakatra plantations and the interior of the islands. (William, 1922; Mark, 2019).

2.5 Germany:

Coffee drinking was introduced in Germany around 1670. The beverage made its way to the court of the great elector of Brandenburg in the same year. The first coffee house in Hamburg was opened by an English merchant in 1679-80, spreading the drink to northern Germany. Other cities followed suit: Regensburg in 1689, Leipzig in 1694, Nuremberg in 1696, Stuttgart in 1712, Augsburg in 1713, and Berlin in 1721 (William, 1922; Mark,

2019).

2.6 India:

In India, the history of coffee is fascinating. Baba Budan, an Indian Muslim saint, clandestinely brought seven coffee beans from Mocha, Yemen to Mysore, India during his journey to Mecca. He planted them on the Chandragiri hills. While Baba Budan may not have been the first to introduce coffee to India, it became an established commercial crop by the early 19th century. Indian Arabica coffee, known as Mysore coffee at the time, gained recognition and was exported to Europe via London. India is the world's sixth-largest coffee producer, with most cultivation taking place in the southern states of Karnataka, Tamil Nadu, and Kerala. Coffee is grown under thick canopies in the biodiverse Western Ghats. In the 2016-2017 seasons, India produced 5.5 million bags of coffee. Commercial coffee plantations in southern India were established by British entrepreneurs in the 18th century, transforming the region's forests into coffee-growing areas (Yash Lakhan, 2022).

3. CLASSIFICATIONS OF COFFEE BEANS

The coffee beans are classified into three major groups including the categories like *Coffea Arabica, Coffea Robusta, and Coffea Liberia*. The classification of coffee beans given in the Figure 1.

3.1 Coffee Arabica:

Arabica coffee is part of the Rubiaceae family, and the genus *Coffea* is mostly grown in subtropical and tropical regions (Berthaud, et al., 1988). It consists of 90 to 124 species (Wrigley & Davis, 2011). Arabica coffee originated from the mountain forest of Ethiopia. Arabica is grown in tropical regions with an altitude of over 500m, but preferably from 1000-1500m higher altitudes generally produce a better quality crop. The optimum temperature for Arabica cultivation ranges from 18-25°c. Flowering takes place on lateral and secondary branches. The flower bud to the inflorescences takes around 2.5 months. The inflorescences that develop into flowers are found on one year old wood. The flower buds are dormant until the first rain initiates blossoming. if rains come directly after the harvest the buds can develop into branches. Initiation of flowering typically takes a week to 10 days after the first rains. For the flower to develop into a fruit it has to be pollinated (pollination is the process where pollen from one flower is transferred to the stigmata of another by wind, insects and gravity). Arabica is largely self-pollinating (this flower from a particular tree can pollinate each other, i.e., there is no difference between male and female flowers).

The leaves of a coffee tree are shiny and waxy and dark green or brownish in colour. The colour and thickness of the leaves vary with age, variety and nutrient status. Leaves form opposite pairs. The underside of the leaf has microscopically small openings called stomata for gas exchange with the atmosphere. Through these opening, the plant can take up CO_2 and release O_2 and water vapour. The majority of cherries contain two beans. The beans have a thin layer called the silver skin and this is surrounded by a hard layer called the parchment. Around the parchment is the pulp (Michiel, et al., 2004).

Most coffee species are diploid (2n=2x=22) and most are self-incompatible, except for coffea Arabica, which is a self-fertile species and a natural allotetraploid (2N=4X=44). Coffea Arabica is a self-pollinating species with a common outcrossing rate of less than 10%. Arabica coffee represents 70% of the world's coffee production. (Philippe, et al., 2009). It is cultivated in over 80 countries and covers over 10.2 million hectares of land in the tropical and subtropical regions of the world, particularly in Africa, Asia, and Latin America (Mishra, et al., 2012).

3.1.1 Propagation:

Propagation of coffee plants involves several steps, including seed propagation, seed tree selection, seedling development, nursery preparation, preparation of soil and planting bags, transplanting, and nursing the seedlings.

3.1.1.1 Propagation by seed:

Propagation by seed begins with carefully selecting seed trees. In the case of Huong Hoa, the criteria for selection include the year of planting of the mother trees. Trees planted between 1993 and 1995 are preferred because they are cloned, of known origin, and have a true catimor genotype. Seed collection should be done from these trees to ensure desirable characteristics. (Michiel, et al., 2004).

3.1.1.2 Seed Tree Selection:

Seed tree selection requires observing potential seed trees over a long period. This step should be initiated at least one year before starting actual propagation (Michiel, et al., 2004).

3.1.1.3 Seedling development:

Seedling development can be carried out in two ways. The first method involves sowing the parchment in a nursery bed, with the flat side of each bean facing downward. Once the seedling starts to develop its first leaf pair, it can be transplanted into soil-filled plastic bags. The second method is sowing the parchment directly in plastic bags. However, this method may result in a poorly developed root system if proper selection is not done (Michiel, et al., 2004).

3.1.1.4 Nursery preparation:

Nursery preparation involves creating a raised plot of land with specific dimensions. The bed consists of a mixture of fertile topsoil and sand. The parchment should be submerged in water with lime to stimulate germination. The sowing depth and spacing between parchments should be maintained. The nursery should be kept dark for the initial stage and then shaded to control light intensity, temperature, and humidity. Protection from strong winds is also important.

After sowing, it takes a few weeks for the root to penetrate the parchment, and another two weeks for the young plant to emerge from the soil. The parchment is shed, and the first two leaves appear (Michiel, et al., 2004).

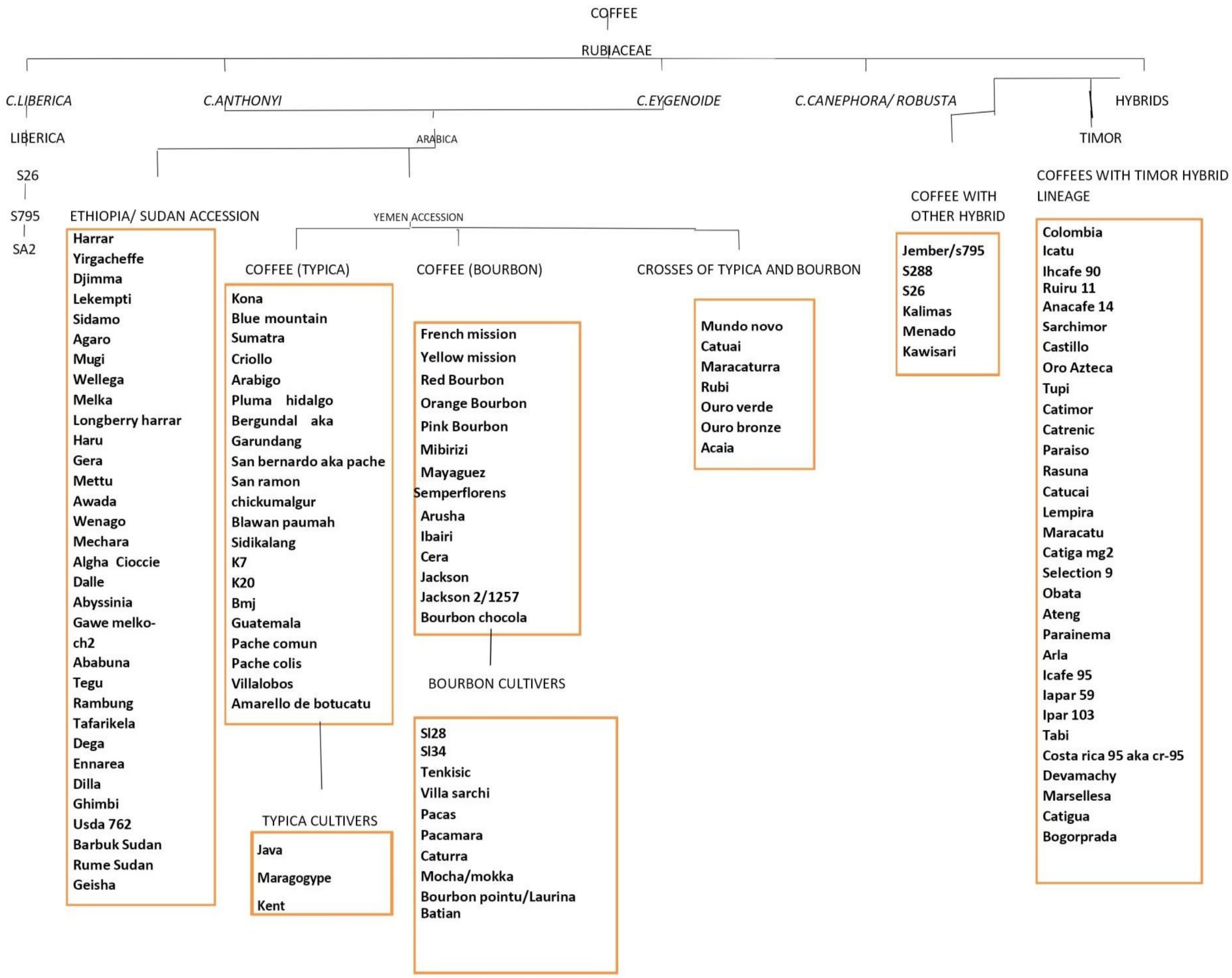

Figure 1: The classification of coffee beans

3.1.1.5 Preparation of soil and Planting bags:

Preparation of soil and planting bags involves using sufficiently large plastic bags filled with a mixture of fertile topsoil, organic manure, and phosphate fertilizer. The soil-manure mixture should be moist but not wet, and proper compaction is necessary to ensure good root development (Michiel, et al., 2004).

3.1.1.6 Transplanting:

During transplanting, seedlings are gently removed from the nursery. Seedlings with double taproots can be maintained by removing one root, and only seedlings with straight taproots should be used. The seedling is lowered into the planting hole in the bag, and the soil is gently compacted to eliminate open spaces around the roots (Michiel, et al., 2004).

3.1.1.7 Nursing the seedling:

Nursing the seedlings involves regulating their growth by using fertilizer and water application. Timing is important, and growth regulation can be done based on seedling health and deficiency symptoms. Pests and fungus should be monitored and managed accordingly. Weed removal and regular watering are also essential. Seedlings are ready for transplanting to the field when they have 5-7 pairs of leaves and reach a certain height. The timing of seedling development should align with the start of the rainy season. (Michiel, et al., 2004).

(a) (b) (c)

Figure 2: Parts of *Coffea Arabica*: a) Flowers; b) Fruits; c) Beans

3.2 Coffee Robusta:

Coffee Robusta, also known as *Coffea Robusta* or *C. canephora*, is a popular variety grown in the highlands of Cavite. It is characterized by large umbrella-shaped growth and thinner leaves with wavy margins compared to Arabica. The Robusta plant produces berries in clusters that are smaller than Arabica, but with similar pulp and parchment thickness. While Robusta is hardier and yields more than Arabica, it is considered to have the poorest flavor and aroma among the four coffee varieties. The plant starts flowering within two to three years after transplantation. *Coffea canephora*, the species to which Robusta belongs, is known for its heat tolerance and resistance to climate change (Jarrod Kath, et al., 2020).

It is a Robusta shrub or small tree growing up to 10m in height, but with a shallow root system *C. canephora* is diploid and self–sterile, producing many different forms and varieties in the wild (Hetzel, 2011).

3.2.1 Propagation:

A cutting is the portion of a mother plant that is collected, treated and planted to develop into a new intact plant complete with stems, leaves and roots. cutting can be collected from mother plants grown in a mother garden and certified by UCDA and NaCORI the tools and equipment for clonal coffee propagation are Quarter rings for the construction of pages, Clear sheet / white polythene sheets (gauge 1000), Polypots of variable size 5 inch by 8 inches, Metallic or plastic labels marked with in the identity of the clone type/varieties e.g.KR1, KR2, KR3…..KR10, Lake sand (free from clay or black soil), Forest black soil, Secateurs (at least 4 pairs), Jerry cans, At least 2 metallic drums for soil steam sterilization, Plastic water drums, Agro – chemicals (fungicides and pesticides, Rooting hormones, Watering can, Wheel barrows, Spades and Hoes (UCDA, 2019).

3.2.1.1 Construction of a propagation cage:

A propagation cage is a structure raising directly potted nodal cutting. The cages are constructed in such a way that they can accommodate 8 filled pots (of size 5 inches by 8 inches) across and should be about 3 feet in width. This is wide enough to enable the polythene sheet to wrap around the cage well and prevent moisture from escaping from it. The height of the cage should be at least 45cm. The cage is constructed using metallic rings, metallic hollow sections, timber and flexible sticks. Metallic iron quarter rings are durable by most nursery operators (UCDA, 2019).

3.2.2.2 Clonal coffee nursery shades:

It is essential to have appropriate shades for rooting and raising rooted cuttings. Constructed rooting said with agricultural shade nets of 70 – 80% (meaning only allowing in 20 – 30 % sunlight). For hardening sheds, constrict the shade with agricultural shade nets of 40-50 % (meaning the net allows in 50 – 60 % sunlight. This is necessary as the rooted cuttings are almost ready to go out into the field. Before placing the clonal coffee cuttings into the sheds, the following processes are completed first (UCDA, 2019).

3.2.2.3 Preparation of rooting media:

Rooting media enhances rooting, shooting of the cuttings and eventually the survival of rooted plantlets. The materials used for rooting media include black forest soil, white lake sand and sawdust.

a. Black forest soil: It is necessary to provide balanced nutrients to the cuttings after they have rooted. The soil should be transported to the site during the dry season, at least three months before use. It is then sieved to remove undesired materials such as stones, plant roots and any other debris. It is then heaped in the sun and covered with a black polythene sheet for solarization to kill pathogenic microorganisms.

b. White lake sand: The sand should have small to medium granules to provide suitable porosity to enable optimum aeration and drainage in the media. It should be free from any traces of clay and left in the sun for at least a month to dry (UCDA, 2019).

c. Saw dust: This is not commonly used these days. However, sawdust is an alternate substitute to lake sand as rooting media. Where sawdust is used, it is best to first leave it heaped in a pit or flat surface and wet it regularly to quicken its fermentation. During fermentation, temperatures may rise to a range of 6^0C to 8^0C (If fermentation occurs in the propagation cages, cutting will die because of heat). Periodic watering of a heap of sawdust maintains the necessary humidity in it. Fermentation activity is checked by introducing a hand into the heap. When the temperature drops (after 6 -12 months), it means the fermentation is over. The sawdust is then rinsed out, by packing in gunny bags and plugging the bags several times in plenty of clean water (UCDA, 2019).

3.2.2.4 Mixing the rooting media:

The medium composed of black forest soil and lake sand mixed in a ratio of 3:1 has been adopted by most nursery operators (UCDA, 2019).

3.2.2.5 Filling rooting media in polypots:

Polypots are filled with the already prepared rooting media and aligned in cage tunnels. In case the nursery operators is using the mixture of sawdust and lake sand media substrate filled in the polypot instead of the sterilized media (UCDA, 2019).

3.2.2.6 Harvesting suckers and preparation of cutting:

Harvesting of suckers is done when the mother bushes have produced mature suckers of pencil thickness. It involves using a pair of sharp secateurs to cut mature suckers from the mother plant. Collecting and heaping them under a shade in the potting preparation shed. Harvested cutting will root well from a semi hard wood tissue, which has not hardened because the interior cells are very active and easy to reproduce (UCDA, 2019).

3.2.2.7 Selection and preparation of cutting:

Select from coffee mother bush that has plenty of suckers, so that if one is removed, it will not harm the mother plant. Use very sharp secateurs or cutting scissors to prevent to the parent plant and severing the cutting rooting edges. Harvest nodal cutting is in the early morning because at this time the plant and ambience are most conductive. Excessive wetness or desiccated tissue will not provide good root cells and the injuries may result in rooting. Prepare nodal cutting are a rectangular semi hard wood section of the sucker. It is possible to obtain 2 or 3 cuttings from one sucker where the mother garden has been properly managed. Nodal cutting is prepared by trimming off 2/3 of the pair of leaves to enable the continuation of photosynthesis of carbohydrates at the base of the cutting. The unnecessary leaves are removed because the new plant has to devote all its energy to developing roots rather than feeding leaves. nodal cutting are trimmed at a slanting angle of 45 at both the upper and lower part to facilitate drainage and rooting. Slanting of the lower part of the cutting prevents injury during placement in the rooting media This facilitates callus formation. Keeping the nodal cutting cool and moist until you have ported them and avoid their direct exposure to sunlight (UCDA, 2019).

3.2.2.7 Application of rooting hormone:

Using a rooting hormone to propagate plant nodal cutting increases the chance that the new nodal cutting in the root thrives. When the rooting hormone is used correctly, it causes the cutting to develop roots quickly and be more robust than cutting that doesn't receive rooting hormone. The application of the rooting hormones follows the following procedure;

1. Remove a freshly, healthy stem cutting from a parent using clean secateurs or shears. Use only cutting from vigorous suckers and make sure the growing tip is between 3 inches and 8 inches long. The cut should be made near a node, which is a slightly swollen knob on the stem remove any leaves or flowers from the node area.
2. Moisten the bottom few inches of the cutting so the rooting hormone will adhere to it. Pour a little rooting powder out of the container and dip the bottom surface of the cutting in the rooting powder. Do not dip the cutting directly into the rooting hormone container. Don't apply the powder any higher than the planting depth. Shake the excess powder off by lightly tapping the cutting against the edge of the container.
3. Plant the cutting in a soilless potting medium. Make a hole in the potting medium with a pencil or similar tool. Make sure the planting hole is wide enough that the rooting hormone is not rubbed off as you sink the cutting into the soil.
4. Press down the soil around the cutting to remove any air pockets and water lightly. Most clonal coffee plants roots better if they are kept out of direct sunlight. Immediately after placement of all the cutting through watering should be done and the propagation cage/chamber is tightly covered with a translucent polythene sheet of gauge 1000 water again only when the condensation on the inside of the polythene sheet begins to disappear. Overwatering should be avoided as this will lead to rooting and death of the cutting.
5. Keep the potted cutting under warm and humid conditions to enable faster rooting and shooting (UCDA, 2019).

3.2.2.8 Placement of cutting in a propagation chamber:

After preparing the cutting, they are properly placed in the rooting media to enable the formation of callus, initiation of roots; shoots and subsequent growth. There are two methods of placement, namely; direct and indirect placement. The most used placement method is the direct method which involves placing the cutting in a polypot filled with rooting media (UCDA, 2019).

(a) (b) (c)

Figure 3: Parts of *Coffea Robusta*: a) Flowers; b) Fruits; c) Beans

3.3 Coffee Liberica

This belongs to the species of *Coffea Liberica* which is locally known as Kapeng Barako or Kapeng Americano. It grows from an upright tree to as tall as 9 m. The plant may be recognized by the leaves that are thicker which excels and twice as long as that of Arabica it has the largest berries among the 4 varieties, berries which are round and borne singly or in small clusters. It is quite resistant to nematodes and tolerant to drought. It begins to bear fruits to five years from transplanting. One hectare of a well-managed liberica coffee plantation could easily yield 1000 kg of clean, dry coffee beans (Jesse, 2005). Originating from the low altitude growing areas of West Africa and Malaysia, it grows as a large tree up to 18 heights, with large leathery leaves and is comparable with *C. Robusta* in flavor (Mark Gibson & Pat Newsham, 2018).

3.3.1 Propagation:

3.3.1.1 Location of the nursery:

The nursery should be located within the proposed plantation or as close to it as possible. It should have a convenient water supply, loose and fertile soil, and good drainage. The nursery should be safe from strong winds and shading should be about 50 percent only (Jesse, 2005).

3.3.1.2 Seedbed:

The seedbed may be one meter wide. The length may depend upon the farmer’s working convenience. A 1x20m plot can accommodate one quintal of seeds. Remove the weeds, roots and stones from the seed bed. The soil should be well-pulverized. A good soil media is a mixture of 1/3 sand 1/3 compost and 1/3 garden soil (Jesse, 2005).

3.3.1.3 Care of seed:

The seedbed should have been watered regularly. In 20-80 days the seeds will germinate. Apply fungicides at the rate of about three tablespoons per gallon of water. Bordeaux mixture or similar fungicides may be used for this purpose. Application should be done weekly until the seedlings are picked for the nursery beds or into plastic bags. When the cotyledons open, spray the seedlings with insecticides as needed (Jesse, 2005).

3.3.1.4 Sowing the seeds:

Sow the seeds in shallow furrows 5 cm apart and about 1cm deep, then cover with a thin fine soil (Jesse, 2005).

3.3.1.5 Hardening:

To get more viable seedlings for picking, hardening of seedlings is done. Reducing the shade and frequently watering the bed when three to four pairs of leaves have emerged will harden the seeding (Jesse, 2005).

3.3.1.6 Pricking:

Pricking is the transferring of seedlings to the nursery beds when they are about 3 to 4 months old or when 3 to 4 pairs of true leaves have emerged. Before pricking prepare and plow the nursery beds. If the seedling will be pricked into a plastic bag, the soil medium should be well pulverized. Transfer seedlings to nursery beds at a 25cm, distance between seedlings. If using polyethylene bags, get size 6" x 8" x 0.002". Plants in plastic bags or nurseries should be under 50 per cent shade (Jesse, 2005).

3.3.1.7 Care of plants in nursery beds or in plastic bags:

Seedlings in the nursery beds or plastic bags should be watered regularly and weeded as the need arises. Inspect and observe for pests and diseases regularly. When leaf eating insects or mealy bugs are observed, spray with insecticides. If fungus disease is observed, spray with a mixture of copper fungicides like Bordeaux mixture (Jesse, 2005).

(a) (b) (c)

Figure 4: Parts of *Coffea Liberica* a) Flowers; b) Fruits; c) Beans

3.3.1.8 Fertilization:

Fertilization seedlings in plastic bag or nursery beds with 3 kinds of urea or 6 kilos of ammonium sulfate for every 1000 plants every 3 to 4 months until they are transplanted in the field. Urea or ammonium sulfate is applied to coffee seedlings in plastic bags by watering the plants with a solution of 150g urea or 300g ammonium sulfate for every gallon of water. Complete fertilizers for those in plastic or nursery beds should be applied at the rate of 3 kilos per 1000 plants every 6 months (Jesse, 2005).

3.3.1.9 Transplanting:

Transplant coffee at the beginning of the rainy season or when the soil is moist. After lining and pegging the field, dig holes and leave these exposed to the weather sometimes. In small planting, putting organic manure in the hole before planting would provide a very good head start for the plant. Healthy seedlings of about one year in the nursery are pulled out or balled from the nursery. When rains during the time of planting, trimming the leaves to about half their size would hasten the recovery of the plant. This could be dispensed with if rains are planties. The stem as well as the tape root of the plant must be set straight in the hole and then covered with topsoil compacted around the base of the plant. Then the topsoil is deep are friable, a point post may be used for digging holes. This is a faster method of planting although it is not the best. In these methods, the coffee seedlings are taken from the nursery with the soil removed from the roots. To lessen root damage, removal of the soil is done by dipping the root system in a can of water until the soil particles are separated from the roots. In this method, planter carries the crowbar and seedlings together. The roots of the seedling are inserted immediately into the hole made by the crowbar, and pressure of the foot is applied on the soil around the plant to close the holes (Jesse, 2005).

4. CHEMICAL COMPOSITION OF COFFEE

The chemical composition of coffee beans is quite complex, and carbohydrates account for the most components. Coffee beans contain a variety of carbohydrates, accounting for 60% of the total weight of raw coffee beans. There are also some proteins, fats, tannins, caffeine, minerals, and other trace ingredients. Variety, origin, and harvest season will affect the composition of these ingredients. The various ingredients of raw coffee beans react chemically during roasting, forming the unique flavours and colours of various coffee beans (Shah Saud & Ahmad Mohammad Salamatulla, 2021).

4.1 Alkaloids:

Caffeine (1, 3, 7-trimethylxanthine) is the main alkaloid component in coffee fruits and the source of the bitter taste of coffee. Caffeine can relieve the amnesia induced by memory loss in the elderly. It can also reduce the risk of neurodegenerative diseases such as Alzheimer's disease (Riedel, et al., 2014) and Parkinson's disease (Liu, et al., 2018). It can also reduce the leakage of blood brain barrier caused by 1- methyl-4- phenyl-1, 2, 3, 6-tetrahydropyridine and inhibit the dysfunction of BBB (Zhou, et al., 2012). Chemical Co Trigonelline is a pyridine derivative found in several types of fruits and seeds, including coffee. It is found in both Arabica and Robusta coffees in an average amount of 1%. It is severely degraded during coffee roasting and when dark roasting conditions are used only about 0.1 to 0.2% remains in the roasted coffee component. For example, N- methyl pyridine (NMP) is a thermal degradation product of trigonelline during coffee roasting (Anwar, et al., 2018).

Table 1: Alkaloid compounds present in coffee bean

S. No.	Compound	Species	Parts
1	Caffeine	CA, CR	L, GB, CB
2	Theobromine	CA, CR	CB
3	Theophylline	CA, CR	CB
4	1,3,7,9-Theacrine	CL	L
5	Libertine	CL	L
6	Methyllibetine	CL	L
7	Trigonelline	CA, CR	GB, CB
8	Nicotinic acid	CA, CR	CB

CA- *Coffea Arabica*, CR- *Coffea Robusta*, CL- *Coffea Liberica*, L- Leaf, GB- Green Bean, CB- Roasted Bean.

Trigonelline has a potential therapeutic effect on the heart tissue of colitis (Caporaso, et al., 2018). Trigonelline can improve cognition and relieve neural loss. It can prevent liver lipid accumulation and lipotoxicity caused by high cholesterol and high fat diet by restoring liver autophagy (Ahmed, et al., 2021). It also inhibits choline intestinal microbial metabolism and its associated cardiovascular risks (Su, et al., 2019). Trigonelline has a neuroprotective effect and is a good drug for the treatment of neurodegenerative diseases (Xu, et al., 2012). Regular doses of caffeine can help ameliorate mild hemiplegic stroke (Fahanik- Babaei, et al., 2018). Caffeine has a protective effect on stroke through its antioxidant and anti-inflammatory properties caffeine has also been associated with diabetes control (Sharma, et al., 2018). In addition, coffee contains theobromine, theophylline, and nicotinic acid (Xue, et al., 2019) and there are also 1,3,7,9- tetramethyluric acid, libertine and methyllibetine in coffee leaves. Table 1 shows the alkaloid compounds of coffee (Van Dijk, et al., 2009).

4.2 Flavonoids:

Flavonoids are a kind of active ingredient widely existing in natural plants, with antioxidant, anticancer, anti-inflammatory and antibacterial activities. Small seed coffee contains flavonoids such as catechin, epicatechin, and quercetin (Wang, et al., 2018). Flavonoid compounds of coffee are given in Table 2.

Table 2: Flavonoid compounds of coffee beans

S. No.	Compounds	Species	Parts
1	Catechin	CA	L
2	Epicatechin	CA	L
3	Epicatechin Gallate	CA	L
4	Epigallocatechin gallate	CA	L
5	Delphinidin-3,5-dilucoside	CA	L
6	Delphinidin-3-(6″-malonyl-glucoside)	CA	L
7	Cyanidin-3-O-glucoside	CA	P
8	Cyanidin-3-O-Rutinoside	CA	P
9	Kaempferol	CA	L
10	Kaempferol-3-Glc	CA	L
11	Kaempferol-3-Glc-Hex-DeHex	CA	L
12	Kaempferol-3-Glc-Hex	CA	L
13	Kaempferol-3-Glc-(6″-Rha)	CA	L
14	Quercetin	CA	L
15	Quercitrin	CA	L
16	Isoquercitrin	CA	L
17	Rrutin	CA	L

18	Hyperoside	CA	L
19	Quercetin-3-Glc-Hex-DeHex	CA	L
20	Quercetin-3-glucuronide	CA	L
21	Luteolin	CA	L
22	Patuletin	CA	L
23	Fisetin	CA	L
24	Myricetin	CA	L
25	Pigenin	CA	L

4.3 Volatile Compounds:

Volatile compounds are responsible for the characteristic aroma of the beverage and are produced during roasting of green coffee, but they are generally degraded in the roasting process by the Maillard reaction. Therefore, the characteristic volatile compounds of roasted coffee are not normally present in the original matrix, but they are produced during the technological process (De Maria, et al., 1999).

This aroma will be formed by an extremely complex mixture of numerous volatile com- pounds that have different qualities, intensities and concentrations.

Volatile Coffee compounds comprise various chemical classes that have been identified in roasted beans: furans, pyrazines, ketones, alcohols, aldehydes, esters, pyrroles, thiophenes, sulfur compounds, benzene compounds, phenol compounds, phenols, pyridines, thiazoles, oxazoles, lactones, alkanes, alkenes and acids, such as other bases (e.g. quinoxalines and indoles), furanone, among others (Sunarharum, et al., 2014). The coffee flavour profile is mainly caused by 2-furfurylthiol, 4-vinyl guaiacol, various alky pyrazines, furanone, acetaldehyde, propanol and the aldehydes from Strecker degradation through the formation of CO2, and many aldehydes are important substances that add flavour and aroma to coffee (Czerny, et al., 1999).

Furans and pyranes are heterocyclic compounds found in large quantities in roasted coffee and include functions such as aldehydes, ketones, esters, alcohols, ethers, acids and thiols. Quantitatively, the first two classes of coffee volatiles are furans and pyrazines, while qualitatively sulfur-containing compounds along with pyrazines are considered the most significant for coffee flavour. About one hundred furans have already been identified in roasted coffee, mainly due to the degradation of glycine present in coffee and characterized by the smell of malt and sweet.

Pyrazines are in an abundant class of compounds present in coffee, with low concentrations that often determine the sensory threshold for coffee flavour. They are derived from the product generated by the Maillard reaction. This compound can be explained by protein degradation through heat and amino acid residues that participate in the Maillard reaction and contribute to the formation of nitrogen-containing compounds, generating the characteristic caramel aroma (Hwang, et al., 2012). Pyridines are described in coffees with roasting intensities and form from the Maillard reaction between an amino acid and a cube of sugar. Notably, the literature argues that in roasted coffee beans under high intensities, pyridines intensify (Moon & Shibamoto, 2009) and contribute to the smoky aroma (Flament, 2001; Ludwig, et al., 2014). Ketones of low molecular weight are abundant and, like aldehydes, decrease during storage of roasted coffee. These substances have widely varying sensory properties. Propanone has a fruit odour, but butane-2, 3-dione has a butter-like aroma. Cyclic ketones, such as 3-hydroxy- 2-methyl-4H-pyran-4-one (maltol) and cyclotene, present odors that may be associated with burnt sugar. Beta-damascenone has a tea and fruit aroma and is considered one of the impact substances for the final coffee aroma (Ludwig, et al., 2014).

Also, as a product of the Maillard reaction, aldehydes and esters are responsible for fruity flavours and maltose notes in coffee, while di ketones contribute to the butter aroma and its derivative, furfuryl alcohol is known to form from monosaccharides, and their flavour characteristics are known to be sweet, sweet bread like, and caramelized. Alcohol is generated by yeast through a metabolite process that reacts with fatty acids to form esters that give the product a tasty odour (Zhang, et al., 2014). Phenolic compounds are formed by the degradation of chlorogenic acids, which are present in large concentrations in green coffee beans. Phenol is one of the most volatile in coffee, its degradation route may suffer much interference, and may generate different volatiles that may or may not be associated with quality, results that may be due to the formation of different precursors Alkenes or alkenes are hydrocarbons responsible for the formation of aromatic rings in coffee. The relative abundance of alkene aromatic hydrocarbons increases with roasting temperature (Fisher, et al., 2015) and its derivatives are associated with coffee aroma.

Coffee plants contain two different types of alkaloids delivered from nucleotides. One type is purine alkaloids such as caffeine (1,3,7-N-trimethylxanthine) and theobromine (3,7-N- dimethyl xanthine); the other is pyridine alkaloid, trigonelinic acid (1-N- methylnicotinic acid). The distribution of caffeine and trigonelline in the plant kingdom is different; Caffeine is present in coffee and tea, but trigonelline is found only in coffee (Patricia, et al., 2021). Esters are the main volatile compounds found in most fruits and are responsible for fruity notes (Kesen, et al., 2013). Table 3 shows the volatile compounds present in coffee.

Table 3: Volatile compounds of coffee bean

S. No.	Compound class	Number
1	Hydrocarbons	80
2	Alcohols	24
3	Aldehydes	37
4	Ketones	85
5	Carboxylic acids	28
6	Esters	33
7	Pyrazines	86
8	Pyrroles	66
9	Pyridines	20
10	Other bases	52

11	Sulfur compounds	100
12	Furans	126
13	Phenolic compounds	49
14	Oxazoles	35
15	Others	20

4.4 Amino acids:

During roasting amino acids play a critical role in the development of colour, aroma, and flavour compounds via the Maillard reaction. Coincidentally it is these very same reactions that are responsible for the aroma produced when grilling a steak or baking a loaf of bread. For example, allowing the cherry to ripen further typically increases the levels of tryptophan, threonine, glycine, tyrosine, serine, alanine, lysine and arginine. Likewise, storage of green coffee at elevated temperatures increases the concentration of several amino acids due to proteolysis and non-enzymatic reactions. Table 4 shows the amino acids present in the coffee.

Table 4: Amino acids present in coffee beans

S. No	Amino acids	Arabica		Robusta	
		Green	Roasted	Green	Roasted
1	Alanine	4.75	4.76	4.87	6.84
2	Arginine	3.61	0.0	2.28	0.0
3	Asparagine	10.63	9.53	9.44	8.94
4	Cysteine	2.89	0.76	3.87	0.14
5	Glutamic acid	19.88	21.11	17.88	24.01
6	Glycine	6.40	6.71	6.26	7.68
7	Histidine	2.79	2.27	1.79	2.23
8	Isoleucine	4.64	4.76	4.11	5.03
9	Leucine	8.77	10.18	9.04	9.65
10	Lysine	6.81	3.46	5.36	2.23
11	Methionine	1.44	1.08	1.29	1.68

12	Phenylalanine	5.78	5.95	4.67	7.26
13	Proline	6.60	6.82	6.46	9.35
14	Serine	5.88	2..60	4.97	0.14
15	Theorine	3.82	2.71	3.48	2.37
16	Tyrosine	3.61	4.11	7.45	9.49
17	Valine	8.05	6.93	6.95	10.47

4.5 Phenolic acids and their derivatives:

At present, p-hydroxybenzoic acid, vanilic acid, p-coumaric acid, ferulic acid and chlorogenic have been separated from Caffeic acid, Caffeoylquinic acid, Dicaffeoylquinic acid, 3- O-feruloylqunic acid. Chlorogenic acid is the main phenolic acid compound, which has the biological function of lowering blood lipid, antioxidant and antibacterial (Asamenew, et al., 2019). The chlorogenic acids also reduce cholesterol, triglyceride, the low-density lipoprotein and increase the high-density lipoprotein (Sittipod, et al., 2019). A blood glucose test for 2 hours of oral glucose in humans confirmed that chlorogenic acids and trigonelline can reduce the early glucose and insulin response. At the same time, the thermal degradation of CGA during coffee roasting leads to the formation of bitter and phenolic aromatic compounds. CGA also participate in the formation of coffee colour through the framework of protein melanin incorporation, which is the main cause of coffee pigmentation and astringency. Table 5 shows the phenolic acids and their derivatives present in the coffee.

Table 5: Phenolic acids in coffee beans

S. No	Compound	Species	Parts
1	Vanillic Acid	CA, CR	L
2	Benzoic Acid	CA, CR	L
3	p-hydroxybenzoic acid	CA, CR	L
4	3- hydroxybenzoic acid	CA, CR	L
5	Gentosic Acid	CA, CR	L
6	Protocatechuic Acid	CA, CR	L
7	Caffeic Acid	CA, CR	GB, CB
8	Sinapic Acid	CA, CR	L
9	Ferulic Acid	CR	GB, L
10	p-coumaric Acid	CA	GB, L
11	Caftaric Acid	CA	L

12	3-O-p-coumaroylquinic Acid	CA, CR	CB, GB
13	5-O-p-coumaroylquinic Acid	CA, CR	GB, CB
14	4-O-p-Coumaroylquinic Acid	CA, CR	GB, CB
15	3-O-Caffeoylquinic Acid	CA, CR	GB, CB
16	4-O-Caffeoylquinic Acid	CA, CR	GB, CB
17	5-O-Caffeoylquinic Acid	CA, CR	GB, CB
18	1-O-Caffeoylquinic Acid	CA, CR	CB
19	1-O-Caffeoylquinic Acid Methyl Ester	CR	GB
20	3-O-Caffeoylquinic Acid Methyl Ester	CA, CR	GB
21	5-O-Caffeoylquinic Acid Methyl Ester	CA, CR	GB
22	3,4-di-O-Caffeoylquinic Acid	CA, CR	GB, CB
23	3,5-di-O-Caffeoylquinic Acid	CA, CR	GB, CB
24	4,5-di-O-Caffeoylquinic Acid	CA, CR	CB
25	3,4-di-O-Caffeoylquinic Acid Methyl Ester	CA, CR	GB
26	3,5-di-O-Caffeoylquinic Acid Methyl Ester	CA, CR	GB
27	4,5-di-O-Caffeoylquinic Acid Methyl Ester	CA, CR	GB
28	3-O-Feruloylquinic Acid	CA, CR	GB, CB
29	4-O-Feruloylquinic Acid	CA, CR	CB, GB
30	5-O-Feruloylquinic Acid	CA, CR	CB, GB
31	1-O-Feruloylquinic Acid Methyl Ester	CA, CR	GB, CB
32	3-O-Feruloylquinic Acid Methyl Ester	CA, CR	GB, CB
33	5-O-Feruloylquinic Acid Methyl Ester	CA, CR	CB, GB
34	3,4-di-O-Feruloylquinic Acid	CR	GB
35	3,5-di-O-Feruloylquinic Acid	CR	GB
36	4,5-di-O-Feruloylquinic Acid	CR	GB
37	3-O-Feruloyl-5-O-Caffeoylquinic Acid	CA, CR	GB, CB

38	3-O-Feruloyl-4-O-Caffeoylquinic Acid	CA, CR	GB, CB
39	4-O-Feruloyl-5-O-Caffeoylquinic Acid	CA, CR	GB, CB
40	3-O-Caffeoyl-4-O-Feruloylquinic Acid	CA, CR	GB, CB
41	3-O-Caffeoyl-5-O-Feruloylquinic Acid	CA, CR	GB, CB
42	4-O-Caffeoyl-5-O-Feruloylquinic Acid	CA, CR	GB, CB
43	3-O-Feruloyl-4-O-p-Coumaroylquinic Acid	CA, CR	GB
44	3-O-p-Coumaroyl -5-O-Feruloylquinic Acid	CA, CR	GB
45	3-O-Caffeoyl-5-O-p-Coumaroylquinic Acid	CR	GB
46	4-O-p-Coumaroyl-5-O-Caffeoylquinic Acid	CA, CR	GB
47	4-O-Caffeoyl-5-O-p-Coumaroylquinic Acid	CR	GB
48	Caffeoyl-N-Tryptophan	CA, CR	GB, CB
49	p-Coumaroyl-N-Tryptophan	CR	GB, CB
50	Feruloyl-N-Tryptophan	CR	GB
51	5-O-Caffeoyl-1,3-Quinide	CA, CR	CB
52	3-O-Caffeoyl-1,5-Quinide	CA, CR	CB
53	4-O-Caffeoyl-1,3-Quinide	CA, CR	CB
54	5-O-Caffeoyl-1,4-Quinide	CA, CR	CB
55	4-O-Caffeoyl-1,5-Quinide	CA, CR	CB
56	5-O-Feruloyl-1,3-Quinide	CR	CB
57	3-O-Feruloyl-1,5-Quinide	CA, CR	CB
58	4-O-Feruloyl-1,3-Quinide	CR	CB
59	4-O-Feruloyl-1,5-Quinide	CR	CB
60	3,4-di-O-Caffeoyl-1,5-Quinide	CA, CR	CB
61	4,5-di-O-Caffeoyl-1,3-Quinide	CA, CR	CB
62	3-O-Caffeoyl-4-O-3-Methylbutanoylquinic Acid	CA	CB

63	3-O-Caffeoyl-4-O-3-Methylbutanoyl-1,5-Quinide	CA	CB

4.6 Chemical constituents present in green, medium roasted coffee beans:

The green and medium roasted coffee beans consist of various numbers of chemical constituents such as trigonelline, chlorogenic acids, sugars, amino acids, proteins, etc. (Clark &Mayer, 1987). Table 6 shows the various constituents of green and medium roasted coffee beans.

Table 6: Various constituents of green and medium roasted coffee beans

S. No.	Components	Green Coffee		Medium Roasted Coffee	
		Arabica	Robusta	Arabica	Robusta
1	Trigonelline	1.0	0.7	1.0	0.7
2	Chlorogenic acid	6.5	10	2.5	3.8
3	Aliphatic	1.0	1.0	1.6	1.6
4	Quinic	0.4	0.4	0.8	0.1
5	Sucrose	8.0	4.0	0	0
6	Alkaloids	1.2	2.2	1.3	2.4
7	Reducing sugars	0.1	0.4	0.3	0.3
8	Lignin	2.0	2.0	2.0	2.0
9	Protein	11.0	11.0	10	10
10	Amino acids	0.5	0.8	0	0
11	Polysaccharides	45.0	50.0	33	37
12	Lipids	16.0	10.0	17	11

4.7 Chemical constituents in various varieties of coffee Arabica and coffee Robusta:

The *coffea Arabica* and *coffea Robusta* consists of various sub varieties (Laura, 2020). The table 7 shows the various chemical constituents present in the various varieties of *coffea Arabica* and *Coffea Robusta*.

Table 7: Constituents in various varieties of coffee beans

S. No	Coffee Variety	Fiber	Lipids	Protein	Caffeine	Chlorogenic Acids	Ash
1	Bourbon	21.75	15.27	13.90	1.15	7.37	3.78
2	Catura	18.85	13.98	14.79	1.13	6.97	3.39
3	Colombia Yellow Fruit	18.45	13.07	14.45	1.16	7.55	3.49
4	Colombia Red Fruit	16.69	14.27	13.92	1.19	7.42	3.52
5	Typica	18.71	13.99	14.59	1.20	6.66	3.43

5. PHARMACOLOGICAL EFFECTS OF COFFEE POWDERS

The coffee powders show various pharmacological effects. Table 8 shows the pharmacological effects of coffee powder

Table 8: Pharmacological effects of coffee powders

Product Name	Coffee (%)	Chicory (%)	Advantages	Disadvantages
Instant Coffee	70%	30%	Rich in antioxidants and is believed to be helpful in weight control weight control instant coffee is also linked to reducing the risk of Neurogenerative diseases such as Alzheimer's and Parkinson. It decreases the risk of type-2 diabetes. It lowers the risk of liver cancer and colorectal cancer- two of the leading cancers in the world.	Caffeine found in the coffee leads to strain in the kidneys. Caffeine is a stimulant, which can cause increased blood pressure and stress on the kidneys. Excessive caffeine intake has also been linked to kidney stones.

Filter Coffee	80%	20%	We add 20% of chicory to the coffee power to create a harmonious balance. It enhances the aroma and imparts a smooth rounded taste. The coffee beans are expertly roasted to perfection, preserving the natural oils and flavours, resulting in a mesmerizing cup of coffee with each brewing.	Robusta coffee beans have a higher concentration of caffeine up to 2.7% of caffeine per bean. The higher caffeine content leads to side effects like anxiety, insomnia, tremors and digestive issues.

6. CHICORY

It is a root of Cichorium intybus a woody, perennial herbaceous plant of the family Asteraceae. Chicory roots are dried, roasted, and ground before being added to coffee as an additive or used as coffee substitute. When chicory is added to the coffee it imparts unique flavour profiles that enhance the overall taste of the brew. When chicory roots are roasted it has a slightly woody and nutty flavour with a hint of caramel like sweetness. The chicory helps to balance the coffee's natural bitterness. The coffee contains about 70-85% of coffee and 15-30% of chicory. This blend not only makes the coffee last longer but also imparts a unique flavour that is slightly sweet and caramel. The chicory extracts are added to alcoholic and non-alcoholic beverages to improve taste (Bais & Ravishankar, 2001).

6.1 Composition of Chicory Root:

The chicory consists of various macronutrients and micronutrients. Table 9 shows the various macronutrients present in the chicory roots, Table 10 shows the mineral content and Table 11 shows the phenolic acids present in the chicory roots (Ifeoma, 2017).

Table 9: Macronutrients in chicory root

S. No	Chemical Composition	Roots (%)
1	Moisture content	75.63 ± 0.39
2	Crude protein	4.65 ± 0.25
3	Crude ether extract	1.69 ± 0.71
4	Ash	4.25 ± 0.11
5	Carbohydrates	89.41 ± 1.07
6	Soluble sugars	11.06 ± 1.00
7	Insulin	44.69 ± 0.88
8	Crude fiber	5.12 ±1.55
9	Dietary fiber	31.15

Table 10: Mineral contents in the chicory roots

Ca (%)	K (%)	Mg (%)	Na (%)	Fe (%)	Cu (%)	Mn (%)	Zn (%)	Pb (%)
181.26 ±4.40	103.7 ±4.62	20.14 ±1.69	67.42 ±2.45	1.77 ±0.21	0.36 ±0.02	0.31 ±0.10	0.39 ±0.03	0.04 ±0.003

Table 11: Phenolic compounds present in the chicory roots

Methanolic Extracts (%)	Total phenolic Content	Phenolic Compound	Percentage (%)
10.75	20.0 ±0.9	Protocatechuic acid	2.50
		Chlorogenic acid	17.84
		p-Hydroxybenzoic	11.04
		Acid Caffeic acid	35.22
		Isovanillic acid	1.97
		p-Coumaric acid	9.65

6.2 Benefits of Chicory:

1. Chicory root is a good source of fiber, which may improve several aspects of digestive health. This is because the chicory roots contain an insulin fiber, a type of prebiotic that promotes the growth of beneficial bacteria in the gut (Madrigal, 2007).
2. It may also improve the bowel function and reduce the constipation.
3. It promotes controlled blood sugar levels by improving how the body metabolizes carbohydrates and decreasing insulin resistance.
4. It may decrease inflammation.
5. It provides a degree of appetite control which can help with reducing caloric intake, and contribute to weight loss (Lizzie Streit, 2019)

6.3 Limitations of Chicory:

1. Excess chicory consumption can exaggerate gallstones by unknown mechanism.
2. If consumed in excess, the high amount of fiber in chicory can cause abdominal pain, flatulence, bloating, and other digestive problems (Ifeoma, 2017)

7. CONCLUSION:

Coffee is a beverage that is widely used throughout the world. Among the all varieties of coffee, the *Coffea Arabica* and *Coffea Robusta* are mostly used. The coffee contains various chemical compositions such as flavonoids, alkaloids, phenolic compounds, and so on. The coffee is used with are without chicory. The normal proportion of coffee and chicory is about 70: 30. The several advantages of coffee are increasing metabolism, helping with type 2 diabetes, beneficial for weight management, lowering the risk of depression, protect liver function some of the disadvantages of coffee are insomnia, nervousness, and restlessness, stomach upset, nausea and vomiting, increased heart rate and breathing rate.

REFERENCES:

[1] Adriana Farah, Thiago FS, The coffee plant and beans, Coffee in Health and Disease Prevention, Elsevier, 2015.

[2] Ahmed MAD, Mohanad M, Ahmed AAE, Aboulhoda E, El-Awdan SA, Mechanistic insights into the protective effects of chlorogenic acid against indomethacin-induced gastric ulcer in rats, Modulation of the cross talk between autophagy and apoptosis signaling, Life Sciences, 2021,275:119370.

[3] Anwar S, Bhandari U, Panda BP, Dubey K, Khan W, Ahmad S, Trigonelline inhibits intestinal microbial metabolism of choline and its associated cardiovascular risk, Journal of Pharmaceutical and Biomedical Analysis, 2018,159:100-112.

[4] Berthaud J, Charrier A, Genetic resources of Coffea, 1988:1-42.

[5] Caporaso N, Whitworth MB, Grebby S, Fisk ID, Nondestructive analysis of sucrose caffeine and trigonelline on single green coffee beans by hyper spectral imaginng, Food Research International, 2018,106:193-203.

[6] Clark Mayer, IARC Monograph, 1987, 51: 65-66.

[7] Czerny M, Mayer F, & Grosh, W, Sensory study on the character impact odorants of roasted arabica coffee, Journal of Agricultural and Food Chemistry, 1999,47: 695–699.

[8] De Maria CAB, Moreira RFA, & Trugo LC, Componentes volateis do cafe torrado, Parte I: compostos heterociclicos, 1999:22.

[9] Fahanik Babaei J, Baluchnejadmojarad T, Nikbakht F, Roghani M, Trigonelline protects hippocampus against intracerebral Aβ(1-40) as a model of Alzheimer’s disease in the rat insights into underlying mechanisms, Metabolic Brain Disease, 2018,34:191- 201.

[10] Fisher A, Du S, Valla JA, Bollas GM, The effect of temperature, heating rate, and ZSM-5 catalyst on the product selectivity of the fast pyrolysis of spent coffee grounds, Royal Society of Chemistry Advances, 2015,1:1–9.

[11] HP Bais & GA Ravishankar, Cichorium intybus L- cultivation, processing, utility, value addition and biotechnology, with an emphasis on current status and future prospects, Journal of the Science of Food and Agriculture, 2001,81:467-484

[12] Hetzel A, Fine Robusta Standards and Protocols, Coffee Quality Institute: Uganda Coffee Development Authority, 2011; 28-32.

[13] Hwang CF, Chen CC, Ho CT, Contribution of coffee proteins to roasted coffee volatiles in a model system, International Journal of Food Science and Technology,2012, 47(10): 2117–2126.

[14] Ifeoma CN, Karabo Shale, Matthew CA, Chemical Composition and Nutritive Benefits of

Chicory(Chichorium intybus) as an Ideal Complementary and Altrenative Livestock Feed Supplement, The Scientific World Journal, 2017: 1-11.

[15] Jesse D. Dagoon, Agriculture and Fihery Technology, 2005: 59-61.

[16] Kesen S, Kelebek H, Selli S, Characterization of the Key Aroma Compounds in Turkish Olive Oils from Different Geographic Origins by Application of Aroma Extract Dilution Analysis (AEDA), Journal of Agricultural and Food Chemistry, 2013,62: 391– 401.

[17] Laura STV, Johanna ASJ, Katherine Martinez, Coffee By Products; Nowadays and Perspectives 2020.

[18] Liu L, Du X, Zhang Z, Zhou J, Trigonelline inhibits capase 3 to protect β cells apoptosis in streptozotocin-induced type 1 diabetic mice, European Journal of Pharmacology, 2018,836:115-121.

[19] Lizzie Streit, Benefits and Uses of Chicory Root Fiber,2019.

[20] Ludwig IA, Sanchez L, De Pena MP, & Cid C, Contribution of volatile compounds to the antioxidant capacity of coffee. Food Research International, 2014,61: 67–74.

[21] Madrigal L & Sangronis E, Insulin and derivates as key ingredients in functional food, Archivos Latinoamericanos de Nutricion, 2007,57:387-396.

[22] Mark Gibson, Pat Newsham, Food Science and Culinary Arts, 2018.

[23] Mark Pendergrast, Uncommon grounds, The history of Coffee and How it Transformed out World, 2010.

[24] Martins SCV, Araujo WL, Tohge T, Fernie AR, DaMatta F M, In High-Light- Acclimated Coffee Plants the Metabolic Machinery is Adjusted to Avoid Oxidative Stress Rather than to Benefit from Extra Light Enhancement in Photosynthetic Yield, 2014.

[25] Michiel Kuit, Nguyen VT, Don Jansen, Manual for Arabica cultivation, 2004:7-22.

[26] Moon JK, & Shibamoto TY, Role of roasting conditions in the profile of volatile flavor chemicals formed from coffee beans, Journal of Agricultural and Food Chemistry, 2009,57: 5823–5831.

[27] Patay EB, Nemath T, Nemath TS, Histological and Phytochemical studies of Coffea benghalensis B. Heyne ex Schult, compared with Coffea Arabica L. Farmacia journal, 2016,64:125-130.

[28] Patrica FP, Carlos AP, Vanessa MO, Lucas LP, Chemical Constituents of Coffee, Quality determinants in coffee production, 2021: 209-254.

[29] Riedel A, Hochkogler CM, Lang R, Bytof G, Lantz I, Hofmann T, Somoza V N-Methylpyridinium, a degradation product of trigonelline upon coffee roasting, stimulates respiratory activity and promotes glucose utilization in HepG2 cells, Food and Function,2014,5:454-462.

[30] Shah Saud and Ahmad MS, 2021, Relationship between the Chemical Composition and the Biological Functions of Coffee, Molecules, 26: 7634.

[31] Shao X, Chen C, Miao C, Yu X, Li X, Geng J, Fan D, Lin X, Chen Z, Shi Y, Expression analysis of microRNAs and their target genes during experimental diabetic renal lesions in rats administered with ginsenoside Rb1 and trigonelline, Die Pharmazie, 2019,74:492-498.

[32] Sharma L, Lone NA, Knott R, Hassan A, Abdullah T, Trigonelline prevents high cholesterol and high fat diet induced hepatic lipid accumulation and lipo-toxicity in C57BL/6J mice, via restoration of hepatic autophagy, Food and Chemical Toxicology, 2018,121:283-296.

[33] Shu Y, Liu JQ, Peng XR, Wan LS, Zhou L, Zhang T, Qiu MH, Characterisation of Diterpenoid

Glucosides in Roasted Puer Coffee Beans, Journal of Agricultural and Food Chemistry, 2014,62:2631-2637.

[34] Su M, Liu F, Luo Z, Wu H, Zhang X, Wang D, Zhu Y, Sun Z, Xu W, Miao Y, The Antibacterial Activity and Mechanism of Chlorogenic Acid Against Foodborne Pathogen Pseudomonas aeruginosa, Foodborne Pathogens and Disease, 2019;16:823– 830.

[35] Sunarharum WB, Willians DJ, & Smyth HE, Complexity of coffee flavor: A compositional and sensory perspective, Food Research International, 2014, 62:315– 325.

[36] Van Dijk, AE Olthof, MR Meeuse, JC Seebus, E, Heine RJ, van Dam RM, Acute effects of Decaffeinated Coffee and the Major Coffee Components Chlorogenic Acid and Trigonelline on Glucose Tolerance, Diabetes Care, 2009,32:1023-1025.

[37] Wang X, Peng X, Lu J, Hu G, Qiu M, Ent-kaurane diterpenoids from the cherries of Coffea Arabica, Fitoterapia, 2018,132: 7–11.

[38] Wang X, Peng XR, Lu J, Hu GL, Qui M, Identification of new diterpene esters from green Arabica coffee beans, and their plantlet aggregation accelerating activities, Food Chem, 2018, 263:251-257.

[39] William H. Ukers, All About coffee, 1922: 5-45.

[40] Xu JG, Hu QP, Liu Y, Antioxidant and DND-Protective Activities of Chlorogenic Acids Isomers, Journal of Agricultural and Food Chemical, 2012,60: 11625-11630.

[41] Xue Y, Huang F, Tang R, Fan Q, Zhang B, Xu Z, Sun X, Ruan Z, Chlorogenic acid attenuates cadmium-induced intestinal injury in Sprague–Dawley rats. Food and Chemical Toxicology, 2019,133:110751.

[42] Yash Lakhan, The Journey of Coffee in India, 2022.

[43] Yebirzaf YM, Semagn AK, Coffee (Coffea Arabica L.): Methods, Objectives, and Future strategies of Breeding in Ethiopia, Sustainability, 2021,13(19): 10814.

[44] Zhang Y, Huang M, Tian H, Sun B, Wang J, & Li Q, Preparation and aroma analysis of Chinese traditional fermented flour paste. Food Science and Biotechnology, 2014, 23(1): 49–58.

[45] Zhang YH, Fu XP, Liang WJ, Antioxidant activity and composition of anthocyanins of crude extracts from Yunnan Arabica coffee husk. Food Science and Technology, 2016,41:219-223.

[46] Zhou JY, Zhou SW, Protection of Trigonelline on Experiments Diabetic Peripheral Neuropathy, Evidence Based Complementary and Alternative Medicines, 2012:1-8.