

Cup'O Joe and the Caffeine Buzz

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The good Lord has provided us little nuggets of enticements strewn all over the surface of the earth just awaiting discovery and application. As is the nature of free choice, some of these nuggets will get you into trouble, but most will be socially acceptable, benign addictions and pleasures that add variety and fun to one's life.

Such is the lowly coffee bean and it's core component of pleasure, caffeine.

This paper will provide you a hopefully entertaining tour of just what is coffee, where is it grown, how much is consumed, how is it merchandised and finally some fascinating information about the compound caffeine.

Per the Coffee Research Institute, the coffee plant is a woody perennial evergreen that belongs to the Rubiaceae family. Two main species are cultivated today. *Coffea Arabica*, known as Arabica coffee accounts for 80% of the world's production. *Coffea Canephora*, also known as Robusta coffee is a more resilient plant than the Arabica, but produces an inferior tasting beverage. The coffee plant can grow to heights of 10 meters if not pruned, but producing countries maintain coffee at three meters to ease harvest.

Three to four years after the coffee is planted, sweetly smelling flowers grow in clusters in the axils of the leaves. Fruit is produced only in the new tissue. The arabica species is self-pollinating, whereas the Robusta species depends on cross-pollination. About 6-8 weeks after the flowers are fertilized, cell division occurs and the fruit remains as a pinhead-sized object for a period that is dependent upon the climate. The ovaries will then develop in a rapid growth period that takes about 15 weeks after flowering. During this time the integument (outer coating) takes on the shape of the final bean. After the rapid growth period, the integument is fully-grown and will not increase in size.

The endosperm remains small until about 12 weeks after the flowering. At this time it will suppress, consume and replace the integument. The remnants of the integument are what make up the silver-skin. The endosperm will have completely filled the cavity made by integument 19 weeks after flowering. The endosperm is now white and moist, but will gain weight during the next few months. During this time the endosperm attracts more than 70% of the total photosynthesis produced by the tree. The mesocarps will expand to form the sweet pulp that surrounds the bean. The formed cherry will change color from green to red about 30 to 35 weeks after flowering.

According to our friends, that we'll soon learn more about, Starbucks, the history of coffee is as rich as the brew itself, dating back more than a thousand years. The first coffee plants are said to have come from the Horn of Africa on the shores of the Red Sea. Originally, coffee beans were taken as a food and not as a beverage. East African tribes would grind the coffee cherries together mixing the results into a paste with animal fat. Rolled into little balls, the mixture was said to give warriors much-needed energy for battle. Later, around the year 1000 AD, Ethiopians concocted a type of wine from coffee berries, fermenting the dried beans in water. Coffee also grew naturally on the Arabian Peninsula, and it was there, during the 11th century that coffee was first developed into a hot drink.

The so-called stimulating properties of coffee were thought by many during these ancient times to give a sort of "religious-ecstasy" and the drink earned a very mystical reputation, shrouded in secrecy and associated with priests and doctors. So, it is not surprising that two prominent legends emerged to explain the discovery of this magic bean.

According to popular lore, a goat-herder noticed that his herd became friskier than usual after consuming the red cherries of a wild coffee shrub. Curious, he tasted the fruit himself. He was delighted by its invigorating effects, and was even spotted by a group of nearby monks dancing with his goats. Soon the monks began to boil the bean themselves and use the liquid to stay awake during all-night ceremonies.

The other popular “discovery” story is about a Muslim dervish who was condemned by his enemies to wander in the desert and eventually die of starvation. In his delirium, the young man heard a voice instructing him to eat the fruit from a nearby coffee tree. Confused, the dervish tried to soften the tree’s beans in water, and when this failed, he simply drank the liquid. Interpreting his survival and energy as a sign of God, he returned to his people, spreading the faith and the recipe. Native desert goat milk had a natural froth under the desert sun, thus this legend dervish, I speculate, enjoyed an early form of the popular latte coffee beverage.

The cultivation of coffee began sometime in the fifteenth century, and for many centuries to follow, the Yemen province of Arabia was the world’s primary source of coffee. The demand for coffee in the Near East was very high. The beans leaving the Yemeni port of Mocha for trade with Alexandria and Constantinople were highly guarded. In fact, no fertile plants were allowed to leave the country. Despite the restrictions, Muslim pilgrims from across the globe during their pilgrimage to Mecca managed to smuggle coffee plants back to their homelands, and coffee crops soon took root in India.

Coffee also made its way to Europe around this time through the city of Venice (are you picking up these current merchandizing handles?) where fleets traded perfumes, teas, dyes and fabrics with Arabic merchants along the Spice Route. The beverage eventually gained popularity with the masses when street lemonade vendors began selling it in addition to cold beverages. Many European merchants grew accustomed to drinking coffee overseas and brought in back with them.

By the middle of the 17th century the Dutch dominated the world’s merchant shipping industry, and they introduced large-scale coffee cultivation to their colonies in Indonesia on the Islands of Java, Sumatra, Sulawesi and Bali. Coffee arrived in Latin America several decades later, when the French brought a cutting of a coffee plant to Martinique. But, when a rare plant disease spread through the coffee fields of Southeast Asia in the mid 19th century, Brazil emerged as the world’s foremost coffee producer.

Where is coffee grown?

Today most coffee is grown on the African, Arabian, Latin American, and Tropical Pacific Ocean continents and islands.

For Arabica coffee there are two optimal growing climates; subtropical and equatorial. In subtropical regions growing altitudes are between 1,800 and 3,600 feet above sea level. Generally there is only one growing season and maturation is generally in the fall time of the year. Countries in this region are Mexico, Jamaica, and the San Paulo and Minas Gerias region of Brazil and Zimbabwe.

The equatorial regions grow at 3,600 and 6,300 feet and frequent rain provides a continuous flowering process and provides two harvests a year. There is so much rain in these growing climates, mechanical drying processes must be employed. Countries in these climates include Kenya, Columbia and Ethiopia.

For Robusta coffees, a lower altitude is generally found at sea level up to 3,000 feet in an area plus or minus 10 degrees from the equator.

Harvesting

Each year (or two in equatorial regions) coffee is harvested during the dry season when the coffee cherries are bright red, glossy, and firm. Ripe cherries are either picked by hand, stripped from the tree with both unripe and overripe beans, or all the beans are collected using a harvesting machine. These processes are called selective picking, stripping, and mechanical harvesting, respectively. No where in my research did I find the name Juan Valdez.

To maximize the amount of ripe coffee harvested, it is necessary to selectively pick the ripe beans from the tree by hand and leave behind unripe, green beans to be harvested at a later time. In Brazil, harvesting the same tree several times is more cost prohibitive than separating and discarding the unripe or overripe cherries. Therefore, Brazil growers typically harvest using the stripping method when 75% of the crop is perfectly ripe. Stripping is feasible and cost effective in Brazil due to the uniform maturation of Brazilian coffees. In stripping, the beans are pulled from the tree and fall to the ground where they are caught by cloth sheets. The beans are removed from the tree debris by tossing the coffee in the air allowing the wind to carry away sticks and leaves. The coffee is then put in 60 liter green baskets, which is the means by which wages are calculated. Fair wage standards have been enforced by major buyers such as the Starbucks Coffee Company, and Starbucks makes this “social responsibility” feature of their company a major merchandising variable.

About 12-20 kg of export ready coffee will be produced from every 100 kg of coffee harvested.

Annual Shipments

Export ready coffee is measured in 60 Kg bags. A kilogram is about two pounds, so a unit of shipment is 120 pounds.

Brazil is the largest producer in the world with 23,135,000 exported shipping units. (Per the Coffee Research Council)

The next five, in order of shipments units are:

Columbia	9,995,000
Indonesia	5,084,000
Guatemala	4,669,000
Mexico	4,358,000
Uganda	3,841,000

Processing, Roasting, Grinding and Brewing

Irrespective of the harvesting method, green coffee beans and overripe coffee cherries inevitably end up mixed with the perfectly ripe cherries and must be separated. Overripe and undeveloped coffee cherries, sticks and leaves float in water. Ripe beans and green coffee cherries are dense and sink. Therefore the first separation step takes place by separating the floaters from the sinkers. The floaters are usually sent directly to a drying patio and burned. The ripe and green cherries are also sent to drying patios to dry naturally or can be sent to pulping machines.

The first stage of pulping is used to remove the green cherries from the ripe cherries. In the pulping machine the internal pressure is monitored to push the coffee against a screen with holes only large enough for a coffee bean (not the cherry) to pass. Since the ripe cherries are soft they break and the seed is released through the screen.

The green cherries are hard and cannot be pulped and are collected and separated from the ripe beans. The pressure inside the pulping machines regulated how many cherries will be processed. Processors regulate adequate pressure by hitting a 3% unpulped ripe cherry percentage per batch. Too much pressure will destroy the bean, rendering it useless.

Fermentation or natural drying is the next step. All pulped beans will contain a small amount of an outer film called mucilage (primarily protopectin, sugars and cellulose). Natural drying, with mucilage, is a useable commodity, but most beans have their mucilage removed via a fermentation process that takes place in vats of water for about 36 hours. Another density separation phenomena results and higher quality beans will sink faster than lower quality beans. If the hours of soaking exceed 36 hours over-fermentation occurs and "stinker" bean results....this must explain bad coffee served in fast food restaurants and hospitals.

After fermentation, the beans are dried on the drying patio and moisture is reduced to an 11-12% water content. Generally, a 100-gram sample is roasted and graded as to quality.

Roasting is the next step and it is here where aromatics, acids and other flavors components are either created, balanced or altered in a way that

should augment the flavor, acidity, aftertaste and body (the primary grading categories of the final coffee beverage).

At 200 centigrade degrees the bean doubles in size and becomes a light brown color and loses about 5% of its weight. At 220 centigrade the bean turns a medium brown and loses an additional 15% of original weight. At this stage an organic process called pyrolysis occurs changing the chemical composition of the bean as well as releasing CO₂.

At 230 centigrade color changes to medium-dark brown and the bean take on an oily sheen. Beyond 240 centigrade beans turn black and lose aromatic compounds and are oxidized resulting in poor blending, dirty brewing machines and stale taste...only in America is this black bean popular.

Grinding is the last step before brewing. Beans should generally not be ground for more than two minutes or major oxidation results.

Grinders are of two primary types; the blade type and burr. The blade, while cheaper, grind unevenly. Burr type grind evenly and clean easier.

Brewing is as much an art as a science. The history of coffee brewing devices is rich and methods of brewing are culturally dependent. Of the thousands of coffee machines and brewing devices invented since the advent of coffee consumption only a few have gained worldwide popularity.

The most popular methods are the French Press, Vacuum Pot, Automatic Drip Brewer and the Espresso machine.

Each brewing method requires a different grind size. Drip coffee requires a medium grind, espresso-fine-grind, French-large grind, and vacuum pot, a medium grind.

Coffee, regardless of type of brewer, should not be brewed for longer than 4.5 to 5 minutes using a ratio of 55 grams of coffee per liter of filtered water at a temperature of 195 to 205 F...or about 2 tablespoons of coffee per six ounces of water. Yes, freshness of water counts, and either filtered or natural spring water should be used as municipal water imparts an off-flavor to the brew. Natural minerals removed from distilled water also hinder a good brew.

Connoisseurs of coffee prefer the French Press because of the excellent extraction of the oils from the bean and the lack of a paper filter. The use of the term “press” relates to the French Press containing a plunger that drives the aromatic coffee from the grounds in a higher ratios.

The Vacuum Pot technique also delivers a high ratio coffee to grounds results, does not require paper filters and has fewer grounds remaining in the coffee cup than the French Press machine. The Vacuum pot is a two-glass vessel machine where the upper vessel contains water and ground coffee. The dry lower vessel draws the brew through a vacuum brought about by natural cooling when the assembly is removed from the heating surface.

The least expensive, but most popular machine, is the Automatic Drip Brewer where a paper filter is required that contains the ground coffee. Generally the water is poured over the top of the coffee grounds and gravity pulls the combined liquid to a waiting carafe.

The preparation of espresso is the most finicky, however the most pleasing to a differentiating coffee lover. The use of a rather complicated machine that can deliver 95C degree filtered water to tamped fine blended espresso ground coffees at 10 atmospheric pressure units in a 30 second process is truly an art. The result is a strong, but sweet brew that is slightly thicker than regular brew and is served in a small thick walled cup. Serious espresso lovers can be compared to those who savor a fine glass of wine.

Caffeine (Pharmacology and Chemistry)

Chemically, caffeine is 1,3,7 trimethylxanthine, a xanthine molecule with methyl groups replacing all of the three hydrogen's bound to the four nitrogens in the xanthine ring. Caffeine is metabolized in the liver. The half-life of caffeine during metabolism is about 5 to 6 hours.

A typical eight-ounce cup of coffee contains about 100 mg of caffeine, or about twice the amount contained in a cup of tea or a can of soft drink.

Caffeine is generally found in some plants to provide a natural insecticide for protection from harmful insects like mealworms, mosquitoes and tobacco hornworms.

In the body, xanthine is a breakdown of the product adenine and guanine, the two-purine constituents of DNA and RNA. Adenosine is an adenine molecule attached to a ribose or deoxyribose sugar molecule. The similarity in chemical structure between the adenine portion of an adenosine and caffeine molecule is the key to how caffeine works. Cells, including neurons, have adenosine receptors. The caffeine molecule is similar enough to adenine to fit into the adenosine receptors, but is not similar enough to stimulate the receptor the same way. So the main action of caffeine is to block the adenosine receptor's normal function.

Adenosine receptors are pervasive across the central nervous system...cerebral cortex, hippocampus, cerebellum and the spinal cord.

Adenosine is a neural modulator, which means it inhibits the release of neurotransmitters, thusly reducing neural activity. So, as caffeine occupies the adenosine receptors, an actual increase in neural activity occurs, thus the "wide awake", or "buzz" feeling we get after a cup or two of our morning coffee. Other physiological effects of adenosine blockage is increased occurrence of vasoconstriction (narrowing of blood vessels), increases of gastric acid and pepsin (heartburn), and increases of free fatty acids, cortisol and epinephrine in the blood. Caffeine is regularly added to analgesics (aspirin) to aid in the efficacy of treating headaches because of its vasoconstriction properties.

Caffeine has not been found, in normal consumption, to increase the occurrence of cancer or cardiovascular disease. There is more carcinogenic effect from the roasting of the coffee bean due to increased amounts of heterocyclic amines. Coffee drinking, in some cases, has shown to actually decrease the occurrence of colon cancer.

Yes, there is a withdrawal effect when reducing caffeine consumption. This effect normally diminishes after three days.... But is it worth it?

There are many articles available attributing caffeine to possible cures of many ailments. One of the more fascinating was the use of caffeine to treat hyperactive children. First glance, that would seem absurd, however the body's natural response to caffeine's blockage of adenosine receptors is to produce more adenosine receptors. Thus, if there are more receptors present in the body, and caffeine is eliminated, normal modulating adenosine activity will reduce hyperactivity.... I would not recommend trying this at home if you have hyperactive kids, just take them to the park.

Consumption

Americans consume about 9.3 pounds of ground coffee per person each year... plus or minus a pound. We run about in the middle of the pack when looking at other countries in the world.

Of thirteen sampled European countries, Sweden ranks as number one with over 24 pounds of ground coffee consumed per person each year.

Rounding out the top five we have (per person):

Denmark	23 pounds
Norway	21 pounds
Finland	20 pounds
Holland	19 pounds

Collective averages within the European Union were slightly higher than the US average measuring 9.7 pounds.

Interestingly, Brazil and Columbia only reported consumption of seven and eight pounds respectively.

One can conclude that coffee consumption is driven markedly by disposable income, and regional consumer taste.

Pricing of coffee is largely affected by supply; all affected by weather, labor/politics and disease conditions. Over the period of 2001 and 2000 combined bean type pricing fluctuated from a low of 47 cents a pound in December 2001 to 82 cents in January of 2000. The price of Arabica, due to its desired taste characteristics carries a price of almost twice that of Robusta, or about \$1.09 per pound vs. 53 cents.

Starbucks and Merchandising

We can't finish a discussion on the subject of coffee without talking about the definitive word in coffee retailing...the Seattle giant Starbucks Corporation.

Starbucks 2004 revenue of \$5.3B was over thirty percent higher than the prior year and 5% increases in same store sales year to year. The remarkable revenue growth is attributable to a rapid growth in new stores which in 2005 was slated for 1,500 locations (including the new store in Hopkinsville).

There are presently 9,000 stores with a plan to increase that total to 30,000 in the next three to five years. 15,000 stores will be built outside of the United States.

There is profit in these stores too. Starbucks reported \$390M in 2004 net income, which is a consistent five percent growth in earnings for the past 13 years.

What is remarkable about this company is its high "brow'd" merchandising strategy that takes the physiological pleasure of drinking a quality brew and associating that pleasure with social, intellectual and Epicurean qualities to make a Starbucks experience more than the standard morning pick-me-up for the harried consumer.

The Starbucks store and merchandising literature is replete with examples of environmental standards for coffee tree plantations, fair wages for labor, investment in communities and, of course, it's status as one of America's Most Admired Companies.

What this means, is a growing base of loyal consumers (it has been reported that morning automobile traffic is snarled around a popular Starbucks store) willing to pay \$2.50 to \$4.00 for that "tall" cup of coffee...and feel darn good about it!

And, oh the buzz.....