Theobroma cacao L

Monograph

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Chapter 1: Introduction

Theobroma cacao beans, is the responsible for the production of cacao which many call "Food of the Gods". Cacao contains over 300 compounds including: protein, fat, carbohydrates, fiber, iron, zinc, copper, calcium and magnesium. In addition, cacao also contains many chemicals that actually increase our “happiness” such as the chemicals phenylethylamine (PEA) and anandamide. Cacao also has an amazing function in our bodies, which lets us feel focused and alert because the consumption of this food increases the rate of your pulse, and you get the feeling of excitement and even of falling in love. Anandamide, also called "chocolate amphetamine", is the cause of changes in blood pressure and blood sugar levels, leading to feelings of excitement and alertness. A lot of benefits right? We are used to consuming tons of chocolate, either white, dark or milk chocolate. But people do not have enough knowledge about these beans.

Throughout this document there are four chapters. The first one talks about its origins, distribution and the environmental factor that are ideal for *Theobroma cacao* to grow properly. The second chapter talks about all the biology of *Theobroma cacao*, from its chromosomes to its sexuality. The third chapter is about propagation and management. In this chapter there are full details on how the plant should be taking care of and how to maintain the cultivation. Finally, the last chapter talks a lot about how *Theobroma cacao* is sold, from chocolate to cosmetics. This last chapter also shows the incredible benefits of these beans in the medical area, and the proper and healthy way to eat chocolate which most people love truly!

Chapter 2: Ecology

2.1 Distribution

The origins, domestication and distribution of *Theobroma cacao* are controversial and difficult to understand because of their wide geographical distribution and human intervention. *T. cacao is native to the Amazon Valley (Rios Napo, Putumayo and Amazonas),* within the limits of Colombia, Brazil and Ecuador where greater genetic diversity of species of *Theobroma* is found. Is widely distributed from southeastern Mexico to the Amazon basin (Ogata, Gómez, & Taube, 2009).

2.1.1 Affinity and Origin

The origin of *Theobroma cacao* is not so certain and there is no evidence of where was cocoa actually born. There are scientific studies for the origin of this tree in many areas in Central and South America. The first hypothesis is the upper Amazon region were tropical rainforests are the primary center of diversity. They say it is possible that cocoa tree grew in this region 10,000 to 15,000 years ago. The second hypothesis is the upper Orinoco region of North East Colombia and North West Venezuela were they found evidence of a large cocoa gene pool in the upper Orinoco. Also in this region, the transfer of *cacao* to Mexico would be short and easy. Another possible origin is the Andean foothills of North West Colombia because of the large number of species found there and the easy dispersal to Mexico. Finally, the last hypothesis is Central America, from southern Mexico to Guatemala were studies show possibilities in the Lacandon forest of Chiapas in Mexico and the Usumacinta river area on the borders of Mexico and Guatemala. Cacao spread through northern South America and Central America. It is said that weather by natural dispersal or carriage, eventually cacao splits into two sub-species, criollo cacao in Central America and forastero cacao in South America (Young, 2013).

Class: Equisetopsida
Subclass: Magnoliidae
Superorder: Rosanae
Order: Malvales

Family: Malvaceae
Genus: *Theobroma*
Species: *Cocoa*

2.1.2 Present Distribution

Today, cacao is cultivated extensively as the unique source of cocoa butter and powder for the confectionery industry. According to the World Cocoa Foundation (WCF), the production of cacao takes place mainly on small-scale farms in developing countries across Africa, Asia, and Latin America. The number of cacao farmers, worldwide, is 5–6 million, and the number of people who depend upon cacao for their livelihood is 40–50 million worldwide (World Cocoa Foundation 2012). The majority of cacao farmers employ a low technology and low-finance approach, bordering on subsistence agriculture.

The last 10 years have witnessed an increasing geographical concentration in cacao growing, with the African region now firmly established as the top supplier (Figure. 1).

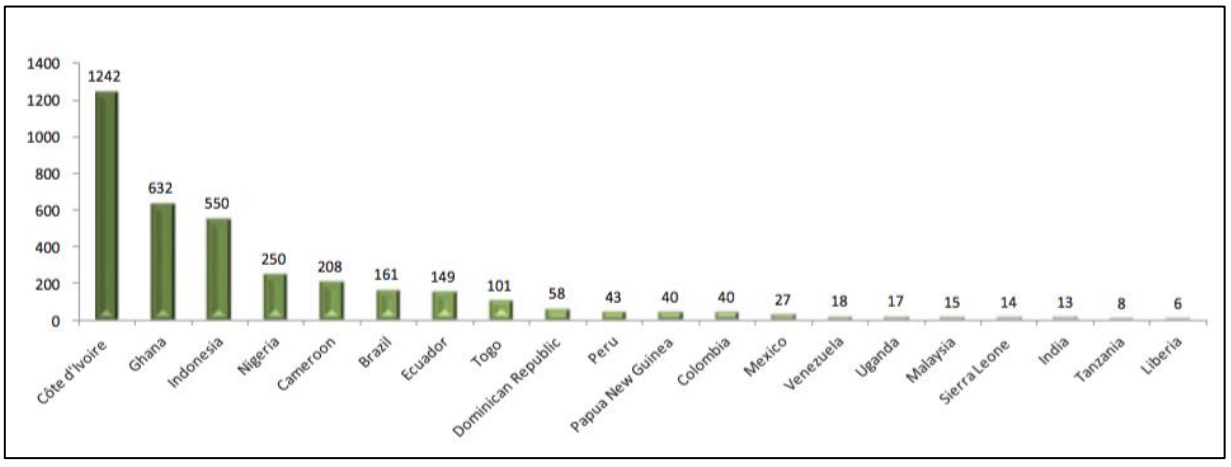

Figure 1. Top 20 cacao-producing countries (ICCO, 2012)

Increased demand has been met by expansion in production, mainly in the major West African cacao-producing countries. The demand for cacao is estimated to exceed supply

with cocoa consumption increasing in emerging middle-income countries, including Brazil, China, Eastern Europe, India, Mexico, and Russia (Federación Nacional de Cafeteros y su Programa de Desarrollo y Diversificación, 1998).

2.2 Environmental Factors Affecting Distribution

2.2.1 Elevation and Climate

The cocoa tree is very particular about where it is grown. Cocoa grows almost exclusively from 20º either side of the equator in an area known as the tropical belt; and because it is rather narrow, the number of countries in which it may be grown productively is very limited.

Annual temperatures between 23º-25º and precipitation of 1500-2500 millimeters are ideal for cocoa cultivation and maintenance (Federación Nacional de Cafeteros y su Programa de Desarrollo y Diversificación, 1998). It is essential to know the average monthly temperature and monthly water balance (precipitation minus evapotranspiration) for cacao because all physiological processes such as vegetative and productive growth are regulated by these factors.

Very strong winds are harmful to cocoa and its effects must be countered with the use of windbreaks by planting suitable trees, such as rubber, walnut, or palms such as Chontaduro, taking into account the direction of the winds and exposure to the sun (Federación Nacional de Cafeteros y su Programa de Desarrollo y Diversificación, 1998).

As indicated any region that meets the conditions listed above, climate and soil, is suitable for cultivation. Areas below 1.300m.s.n.m have excellent characteristics for commercial exploitation of cocoa.

2.2.2 Geology and Soils

Cacao grows best in loose, coarse material for good drainage and root growth. Also, with high nutrient levels and organic matter content to at least a depth of 1.5 meters. The best soils are roughly 50% sand, 30-40% clay, and 10-20% silt sized particles. It is not a drought tolerant plant and needs consistent moisture for the roots; the tree will be at risk of death if it goes longer than three months without at least 100mm rain. In addition, the tree is also sensitive to too much water, and requires proper drainage, otherwise problems such as fungus can develop. The nutrient requirements are mainly that of the three big micronutrients (Nitrogen, Phosphorous, and Potassium) in high quantities and slightly smaller amounts of magnesium and calcium (Wills et al., 1966).

2.3 Vegetation Components

2.3.1 Soil Environment and Effects of Soil

Cacao will tolerate soil ranging from 4.0 to 7.5 in pH, but prefers just slight acidity, with an ideal pH level of 6.5. According to Wessel (1971): *"The soil must be capable of retaining an adequate supply of available moisture during all seasons, while at a time good drainage"*. The finer particles aggregate to large very stable particles of about coarse sand size. Such soils have desirable characteristics: good for free drainage, good aeration and good for retaining relatively high water content. In West Africa very large quantities of gravel are often present within the soil. They cause bifurcation and poor development of the taproot. If the upper layer contains more than 25% gravel a soil is unsuitable for cocoa production. For the lower layers a percentage of more than 40% is unfavorable. A soil suitable for cocoa cropping should be fertile and well supplied with nutrients, especially in the top layer.

2.3.2 Interaction of Plant Roots and Relationship With Animals

Cocoa establishes symbiosis with fungi: *Scutellospora calospora and Glomus mosseae.* Mycorrhizae confer competitive advantage especially in soils with poor nutrient

supply (Kennedy, 2005).

The cacao tree is the master of using other organisms for its benefit. It has developed specific and very effective adaptations that allow it to thrive in its environment, most of which involve taking advantage of its neighbors. Cacao trees live under the shade of taller rainforest trees. *Theobroma cacao* uses this shade to protect its very delicate seeds from sunburn along with wind protection. A more mutualistic relationship occurs between the cacao tree and a few species of midges, the tree's main pollinators (Kennedy, 2005). The tree rewards the midges by producing cherelles, tiny pods that die before they can grow. These immature pods rot and provide the perfect home for its tiny pollinators.

Table 1: Lists of pests and diseases of Theobroma cacao

Scientific Name	Affect on cacao	Type of pest disease	Reference
Sahlbergella singularis	Use extensions of the mouth to suck out nutrients from the tree.	Insect	The Chocolate Tree, 2007.
Helopeltis bergrath	Use extensions of the mouth to suck out nutrients from the tree.	Insect	The Chocolate Tree, 2007.
Moniliophthora perniciosa	Powdery spores and a root disease	Fungus	International Cocoa Organization, 2015.
Phytophthora spp.	Pod Rot, also know as Black Pod	Fungus	International Cocoa Organization, 2015.
Oncobasidium theobroma	Heavy losses of trees in mature plantations	Fungus	International Cocoa Organization, 2015.
Conopomorpha cramerella	The Cocoa Pod Borer (CPB), also known as Cocoa Moth	Insect	International Cocoa Organization, 2015.

Table 2: Lists of beneficial organisms for Theobroma cacao

Beneficial organisms	*Dolichoderus thoracicus*	Reduces the number of other insects that are harmful to the tree along with reducing the instance of black pod disease.	Insect	The Chocolate Tree, 2007.
Beneficial organisms	*Acaulospora scrobiculata and Glomus etunicatus (Endomycorrhizae)*	The tree uses the fungi for increased absorption of nutrients	Fungus	The Chocolate Tree, 2007.

Table 3: Estimated annual reduction in potential cocoa production by major diseases (Bowers, 2001).

Diseases	**Pathogen**	**Region**	**Reduced Production**	
			(tons x 1000)	**($ million)***
Black Pod	*Phytophthora* spp.	Africa/Brazil/ Asia	450	423
Witches' Broom	*Crinipellis perniciosa*	Latin America	250	235
Frosty Pod Rot	*Moniliophthora roreri*	Latin America	30	47
Swollen Shoot	CSSV	Africa	50	28
Vascular-streak dieback	*Oncobasidium the obromae*	Asia	30	28

Another important interaction of the cacao tree involves its adaptation for brightly colored pods. The colors of the seeds attracts the attention of monkeys, squirrels and some birds. Because of this, the tree of *Theobroma cacao* relies on animals to pick its pods and carry them off for seed dispersal. The bitter taste of the seeds prevents them from being eaten and allows for the perfect placement when they are dropped yards away from the tree (The Chocolate Tree, 2007).

Although *Theobroma cacao* is well adapted to the environment it is cultivated on, there are numerous insects and fungi that infect this tropical tree's roots, leaves and pods. Many caterpillar and larvae species munch on the leaves, while other insects take up residence in rotting pods, along with the midges. (The Chocolate Tree, 2007).

Chapter 3: Biology

3.1 Chromosome Complement

"Theobroma cacao L. is a diploid tree fruit species ($2n = 2x = 20$ (ref. 1)) endemic to the South American rainforests" (Argout et al., 2010).

3.2 Life Cycles and Phenology

Theobroma cacao requires rain, humidity and high year-round heat, according Kimberly Sharpe, a freelance writer. They require ongoing protection from the sun and wind, according to the World Cocoa Foundation. Fruit production begins when the tree reaches 5 years old. Pod production accurse after 10 years and continues until the tree reaches 40 years of age.

3.2.1 Seedling Protection

Kimberly Sharpe argues that, cocoa seedlings require protection to thrive until they are 4 years old. Hardwood trees, coconut trees, plantains, breadfruit and banana trees are often planted around cocoa seedlings to offer shade and wind protection. When a cocoa tree has ample shade from the tropical sunlight, its lifespan is often increased to 100 years according to the Chocolate Manufacturers Association (Sharpe, 1997).

3.2.2 Flower Production

The flowers of the cocoa tree are produced throughout the year and grow side by side of the cocoa pods. The flowers have a white or pink color. Flowers are found on the older branches and also on the trunk of the tree. Only 3 percent to 10 percent will ever manage to mature into a fruitful seedpod according to the World Cocoa Foundation. In addition, there is a small insect known as a "midge". This insect is like the chief pollinator

that can increase the production of flowers. The "midge" requires moist, dark, rotting vegetation to survive (Sharpe, 1997).

3.2.3 Foliage and Growth

The foliage of the cocoa tree begins a brilliant red. As the leaves mature they turn green. The tree produces a deep taproot that measures about 3 feet long. It also produces an abundance of horizontal feeder roots that spread out 20 feet around the tree in search of water and nutrients. The tree grows about 50 feet tall (Sharpe, 1997).

3.2.4 Seed Pods

Seedpods mature over 5 to 6 months. Each pod measures between 8 to 14 inches when fully grown. Pods appear in yellow, red, green and purple. Pods often have a speckled appearance when fully grown. Each seedpod contains 20 to 60 seeds embedded in a soft white pulp. The seeds produce cocoa butter (Sharpe, 1997).

3.2.5 Harvest

Harvest takes place year-round when seed pods ripen. The pods are chopped from the tree by hand using a machete. The seed pods are never pulled from the tree because they can do considerable damage to the limbs and trunk by ripping bark and causing a delay in future flower production in the wounded area according to the Queensland Government (Sharpe, 1997).

3.2.2.1 Flowering and fruiting

According to the manufacture company of Barry Callebaout (2016) The cocoa tree can grow as tall as 12-15 m in the wild. But to facilitate harvesting most cocoa farmers do not let it grow higher than 4-8 m. The cocoa tree blooms and bears fruit the whole year round. This means that cocoa has flowers and fruit on the tree at the same time. In two cycles of six months, thousands of delicate flowers adorn the stem and main branches. Only

approximately 40 will eventually develop into fruit. Each flower blooms for only a single day.

Additionally, this company affirms that when a bud matures, the flower starts to open in the afternoon and continues to open during the night. Early the following morning, the flowers are fully open and the male part of the flowers releases their pollen. Then it's up to ants and tiny flies to venture from one flower to the next and pollinate the female part of the flowers. The flowers that get fertilized will develop into cocoa pods over a period of about five months.

Full-grown pods vary significantly in shape, texture and size, and can range from about 15 cm to over 35 cm in length. A ripe fruit typically contains 20 to 75 cocoa beans, each 1 cm to 3 cm long, embedded in a white pulp. Cocoa beans are very nutritious; they consist mainly of fat (50%) and carbohydrates (25%).

3.3 Productivity and Biology

3.3.1 Pollen

Theobroma cacao requires pollen from another tree for successful fruit production, while the flowers themselves have an architecture that seems to "barricade insects from transferring pollen effectively" (Kearney, 2015). The flowers of this plant have "hoods" over the organs that produce pollen. Because of this, there is a restriction in the access to only tiny insects, and the receptor for the pollen. To make matters worse, these insects are weak fliers and have a limited capacity to actually transmit the necessary amounts of pollen from flower to flower (Kearney, 2015).

3.3.2 Sexuality and reproduction

Chavez et al. (2014) explains how cocoa flowers contain both male sex cells as well as female sex cells. An ovule must be fertilized by a pollen grain to become cocoa beans, which are the seeds. Pollination may occur within one flower, between different flowers on

the same cocoa tree, or between different flowers on different cocoa trees taking to note that the flowers must be opened. If pollination does not occur within one or two days the flower dries up and drops off the tree.

3.3.3 Pollination and potential pollinators

Chavez et al. (2014), adds that once pollinated, cocoa beans grow inside a fruit, called a pod. Pods can vary greatly in size and shape, depending on the variety of the tree. Inside the pod, the cocoa beans are covered with murcilage, which is attracted to wild life. Because of this, animals will take the pods and eat the murcilage but do not consume the beans.

3.3.4 Anthesis

When the flowers are fully open and the male part of the flowers release their pollen, it's up to ants and tiny flies to go from one flower to the next and pollinate the female part of the flowers. The flowers that get fertilized will develop into cocoa pods for a period of five months.

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3.3.5 Fruit development and seed set

Frimpong-Anin, Adjaloo, Kwapong and Oduro (2014), describe how the presence of microscopic nectarines on the pedicels, sepals, and guide lines of the petals and staminodes that produce odor make many potential pollinators feel lees attracted, and therefore only insects that have evolved with the plant will successfully pollinate it. The morphological and behavioral characteristics of ceratopogonid midges, however, make them effective pollinators of cocoa.

3.3.6 Ovule development

According to E.E. Cheesmen (1927), from the Department of Botany and Genetics, Imperial College of Tropical Agriculture Trinidad, B. W. I. Genetic studies have proved that normal Mendelian segregation of certain characters occurs in the seedling progeny of some cacao trees. After various studies, there are two factors that are important. The first one is that fertilization does occur. The second one is both self and cross-fertilization are possible.

3.4 Ecophysiology

Cacao varies a lot in morphological and physiological traits. When cocoa reproduces by seed, it displays orthotropic growth patterns. For example, leaf emission occurs in a rhythmic way independent of climate, which indicates that the growth rhythm is under endogenous control. However, after achieving approximately one to 1.2 m in height, the orthotropic growth ceases and the plant emits plagiotropic branches. The number of plagiotropic branches varies from three to five, forming what is generally named the cup or crown of the cacao tree (Plant, 2007).

Chapter 4: Propagation and Management

4.1 Natural regeneration

Theobroma cacao grows best under tropical conditions, with strong light and high humidity to keep the tree moist and prevent weeds. A balanced liquid of leaves should be given during the summer and high potash during the winter (Plant Village, n.d.). Using a propagator set to a temperature of 22 to 23 ˚C, seed can propagate cocoa. Germination should take between 10 and 14 days. ("Theobroma Cacao — the Tree of Life," 2013).

4.2 Nursery Propagation

The cocoa nursery should be kept weed free and supplied with additional nutrients by fertilizing, particularly when trees are grown on poor soils or without shade ("*Theobroma cacao* — the Tree of Life," 2013).

According to PlantVillage, a user moderated Q & A forum dedicated to the goal of helping people grow their own food, organic fertilizers are generally preferable to inorganic ones as they do not deplete the soil organic content and conserve soil structure. The amount of fertilizer required is dependent on many factors, such as the age of the tree and the amount of shading but mature cocoa generally requires at least 50–100 kg/ha of nitrogen, 25 kg/ha of phosphorus, 75 kg/ha of potassium and 15 kg/ha of magnesium each year.

4.2.1 Propagation from seed

Seeds germinate in 5-10 days, but lose viability quickly if they dry out. Seedlings should be grown under 50% shade. Cacao may be cleft or patch grafted.

Cacao is adapted to a humid tropical climate, and grows best in fertile, well drained soils. Trees grow best with light shade, but will grow well in full sun with adequate soil moisture. In its natural habitat, cacao is found growing as a forest understory tree at altitudes up to 3,000 feet (900 m) (A. B. Eskes and Y. Efron & A.B. Eskes and Y. Efron, editors, 2006).

4.2.1.1 Pre-preparation and implications for germination

Frost Tolerance: Needs uniformly high temperatures, green house only in Phoenix, for short duration cold, foliage damaged at 33° F (0.5° C), serious damage at 28° F (-2° C) ("Theobroma cacao," n.d.)

Sun Exposure: Light shade ("Theobroma cacao," n.d.)

Origin: Central America, Mexico ("Theobroma cacao," n.d.)

Growth Habits: Tropical evergreen tree to 25 feet (7.5 m) ("Theobroma cacao," n.d.)

Watering Needs: Abundant water and humidity ("Theobroma cacao," n.d.)

Propagation: Cuttings, budding, grafting, seeds ("Theobroma cacao," n.d.)

4.2.1.2 Sowing and the germination process

The company World Seed Supply, known for offering a wide selection of yage vine seeds, highlights that it is recommended to squeeze the sliced cacao pod to break it fully apart. Afterwards, you will find individual seed coated by a "white fruity material" which is the responsible for the growing of cacao to be difficult because it is an ideal place to harbor molds and disease that could harm the seed during germination. Remove the white material and with a knife scratch the outer skin covering of the seed. Once, the skin has been breached in one area, peel off the entire skin, leaving the dark seed inside. While one seed was being worked on, the other seeds should be put in water to keep from drying out and to keep any of the remaining fruit material workable. Leave them to soak overnight and then, place them in a bed of moist paper towel. Keep the seeds in this medium until the roots are significantly developed.

This company gives various recommendations to continue the sowing and germination of this plant. First, they state that ideally, the root should be at least half an inch before sowing. "This way, you can put the seed itself just above the soil line," in order to decrease the risk of mold outbreak. World Seed Supply recommends to place some moist sphagnum moss around the top to keep the seed head from drying out. Place the planted seed directly under a grow light and, if there is any mold, remove it carefully with peroxide solution and dry the surface of the seed out for a day or two. Once the seed heads arise above the soil, spray it regularly so it can open.

4.2.1.3 Storage

Mark Rieger, from the University of Delaware´s College of Agriculture and Natural Resources, affirms that seed storage behavior has a lot of factors to keep under control. In terms of temperature, the ideal temperature is about 17 deg. C. The seeds tolerate desiccation to 25% mc when dried at 20 deg. C. Seeds stored in pods at 5 or 10 deg. C are killed within 2 days, and there is 100% survival when stored in pods at temperatures of 15-30 deg. C for 3 weeks.

4.2.2 Vegetative propagation

Amano Artisan Chocolate Factory talks about the two main forms of propagation for cocoa trees. The first one talks about how the cocoa pods may be harvested and their seeds used to plant new trees. This form actually helps preserve genetic diversity among the crop. However, this can be a problem on plantations where multiple varieties of cacao trees are present in close proximity because judging when the pods are rope can be difficult due to the fact that cocoa trees typically have a wide variety in the shapes, sizes and colors of their pods.

4.2.2.1 Grafting

Biodiversity International, which delivers scientific evidence, management practices and policy options to use and safeguard agricultural and tree biodiversity to attain sustainable global food and nutrition security, affirms that many farmers prefer to propagate the cacao trees through cuttings. The most common form is through the use of grafting. In this case, a cutting is removed from the tree that is being propagated. A bud is found on the branch that has been removed for cuttings. The bud is typically at a leaf juncture, and if the branch were to grow on its own, this would be where a new branch would form. The bud is cut off the branch in the shape of an “elongated diamond.” The bud is carefully removed, while care is taken not to touch the newly exposed surface area.

Removing a bud for use in grafting

4.2.2.2 Cuttings

Amano Artisan Chocolate Factory states that there are various factors that affect rooting success of cocoa in terms of isolation or in combination with each other because it is often impossible to separate the effect of one factor from the other. Among these factors there is light, temperature, humidity, and the air-moisture. But, the most significant factors are the hormonal treatment, wounding, etiolating, and exogenous supply of carbohydrates and minerals to cuttings. The light intensity at which rooting occurs is dependent on temperature. The relative humidity within the propagation set-up is related to the light intensity and associated temperature. The effects of various media on rooting of cuttings are usually closely influenced by the temperature and water relations.

The most effective hormonal treatment for cacao is a mixture of indole butyric acid (IBA) and naphthalene acetic acid (NAA) in equal proportions at a concentration dependent on the dipping time and the size of cutting. Exogenous application of carbohydrates may improve rooting of cuttings. The need is for an effective manipulation of the external environment and a wider exploitation of some technical factors to improve on rooting in cacao (Amoah, 2006).

4.3 Planting

Jon Vanzile, a member of The Spruce, affirms that cacao has a lot of complications in order to grow properly. For instance, cacao can only tolerate short periods of temperatures below about 60˚F, but it will not thrive and growth will almost stop. In the other hand, prolonged periods of temperatures below 50˚F will prove fatal. It should be taken to note that cacao needs filtered sunlight, very high humidity, plenty of food and water, and warm temperatures. Also, it is recommended to plant two plants in order to fertilize because they cannot do this job by themselves, so a companion plant is required for germination.

In terms of planting there are two main types of cacao that are planted. The first one is the Forestero group, cultivated in West Africa and Brazil. They represent the 80-90% of the world's cocoa plantations. In these cultivars the fruit is rounded and almost smooth, and the pod husks are hard and green with 30 or more seeds per pod. The second is the Criollo group, which represents about 10% of the world's cocoa plantations and grows in the Caribbean, Venezuela, Ecuador and Papua New Guinea. It is, however, the most highly appreciated and the Criollo beans have always been used for the best quality chocolates. The yellow or red pod husks are soft and thin and there are 30 or more seeds per pod (Juan C. Motamayor & Juan C. Motamayor, Philippe Lachenaud, Jay Wallace da Silva e Mota, Rey Loor, David N. Kuhn, J. Steven Brown, Raymond J. Schnell, 2008).

4.4 Management

Management of *Theobroma cacao* is pretty simple but still there are two diseases of importance to cacao. Black Pod and Witches' Broom are the main and almost the only diseases that this tree can have, and so in order to manage these diseases there are various thing to control.

4.4.1 Tending

Amy Grant, member of Gardening, explains the tending of cacao. As the seedling grows, pass them to a larger pot and keep them in a temperature of 18-29 C. Fertilize every

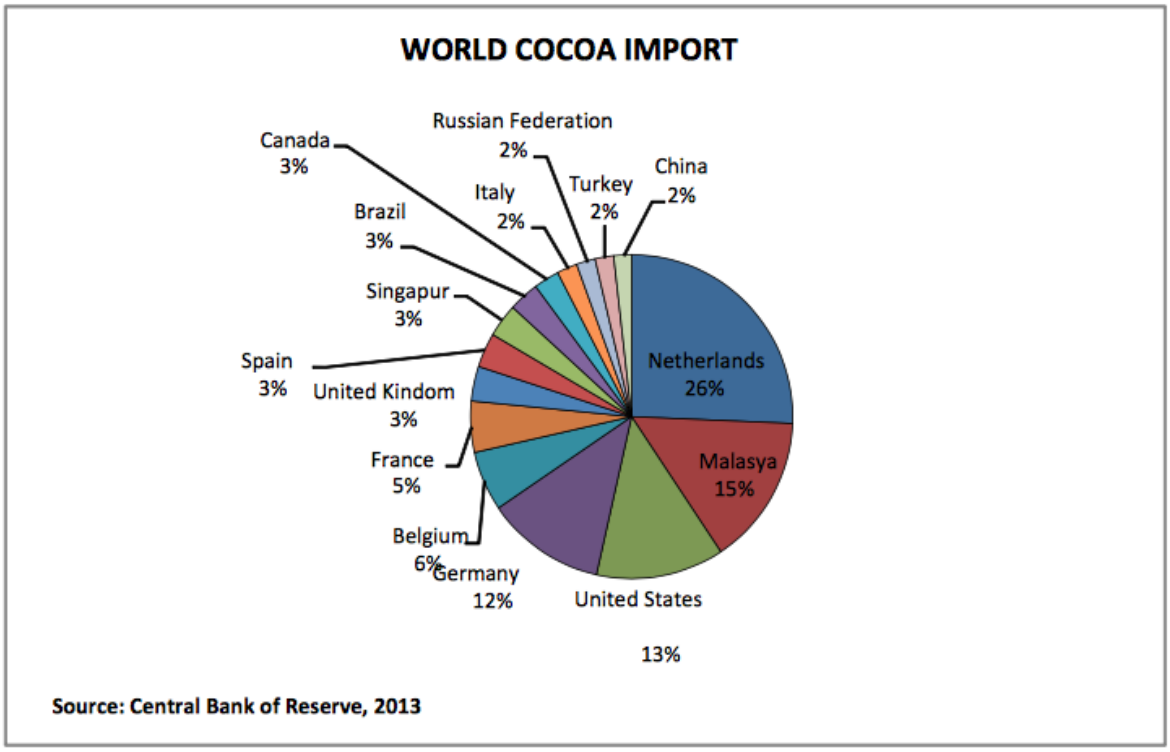
two weeks and located in a humus rich, well-draining area with a pH near 6.5. Place the cacao tree in beside a taller tree in order to provide shade and wind protection. Depending upon rainfall, the cacao will need between 1-2 inches of water per week. Also, fertilize every two months until the tree is a year old. The tree should flower when 3-4 years old and about five feet tall. Hand pollinate the flower in the early morning. They require extensive fermenting, roasting and grinding before you, too, can make a cup of cocoa from your own cacao beans.

4.4.2 Fruiting

Mark Rieger, from the University of Delaware´s College of Agriculture and Natural Resources, describes the fruit of cacao. They are borne singly or in small groups on the main stems and older wood. “The outer portion of the fruit is leathery, usually ridged or lobed, and about 1/4 to 1/2 inch thick.” Seeds are in fleshy, mucilaginous, sweet arils, and have either white (criollo) or purple (forastero) cotyledons. Fruits are either red or yellow at maturity, mature year-round, and are self-thinning.

5.1 Imports and Export of Cocoa

Globally six leading cocoa importing countries are identified, Netherlands 26%, Malaysia 15%, U.S. 13%, Germany 12%, Belgium 12% and France at 5% of total import (Cocoa, 2013).



5.2 Marketing

The World Cocoa Foundation states that after the beans are dried and packed into sacks, the farmer sells to a buying station or local agent. The buyer then transports the bags to an exporting company. The exporting company inspects the cocoa and places it into burlap, sisal, or plastic bags. The cocoa is trucked to the exporter's warehouse near a port. Sometimes additional drying is necessary at this point.

5.2.1 Packing and Transporting

The foundation also explains the exporting company finalizes the time and place for shipment and the beans are loaded onto ships, which then the cocoa is taken to a pier warehouse. Cocoa is stored in bags or bulk in the warehouse. The buyer will conduct a quality check to accept delivery and cocoa is usually stored until requested by the processor or manufacturer.

5.2.2 Consumer

World Cocoa Foundation explains that today, people around the world enjoy chocolate in thousands of different forms, consuming more than 3 million tons of cocoa beans annually. The cocoa, chocolate, and confectionery industry employs hundreds of thousands of people around the world and is a key user of other agricultural commodities such as sugar, dairy products, nuts, and fruits.

5.3 Uses

Cacao seeds are the source of commercial cocoa, chocolate, and cocoa butter. In the preparation of chocolate, this mass is mixed with sugar, flavoring, and extra cocoa fat. Milk chocolate incorporates milk as well. Cocoa butter is used in confections and in manufacture of tobacco, soap, and cosmetics. Cocoa butter has been described as the world's most expensive fat, used rather extensively in the emollient "bullets" used for hemorrhoids.

5.3.1 Chocolate liquor

Eat Halal and Healthy describes chocolate liquor is pure cocoa mass in solid or semi-solid form. Like the cocoa beans from which it is produced, it contains both cocoa solids and cocoa butter in roughly equal proportion. It is produced from cocoa beans that have been fermented, dried, roasted, and separated from their skins. The beans are ground into cocoa mass. The mass is melted to become the liquor, and the liquor is either separated into cocoa solids and cocoa butter, or cooled and molded into blocks known as *raw chocolate*.

5.3.2 Cocoa Solids

Dom Ramsey (2006), chocolate expert, writer, consultant and Academy of Chocolate award winning chocolate maker based in London, has a blog dedicated to the world chocolate, which describes cocoa solids. They are a mixture of many substances remaining after cocoa butter is extracted from cacao beans. When sold as an end product, it may also be called cocoa powder or cocoa. Cocoa butter is 50% to 57% of the weight of cocoa beans and gives chocolate its characteristic melting properties. Chocolate requires the addition of extra cocoa butter to cocoa liquor, leading to an excess of cocoa solids and thus a relatively cheap supply of cocoa powder.

5.3.3 Cocoa Butter

Alison Spiegel (2014), a lifestyle editor of The Huffington Post, described cocoa butter, also called theobroma oil, as "a pale-yellow, edible vegetable oil extracted from the cocoa bean." It is used to make chocolate, as well as some ointments, toiletries, and pharmaceuticals. Cocoa butter has a cocoa flavor and aroma. Its best-known attribute is its melting point, which is just below human body temperature.

5.3.3.1 Extraction and composition

Alison Spiegel (2014) also talks about Cocoa butter and how it is obtained from whole cocoa beans, which are fermented, roasted, and then separated from their hulls. About 54–58% of the residue is cocoa butter. The broma process used to extract cocoa butter from ground cacao beans. Cocoa butter contains a high proportion of saturated fats and has no more than trace amounts of caffeine and theobromine. Some food manufacturers substitute less expensive materials such as vegetables oil and fats in place of cocoa butter.

5.3.4 Chocolate

The National Confectioners Association (2017) is the trade organization that advances, protects and promotes chocolate, candy, gum and mints, and the companies that make these special treats. They talk about chocolate and its types. Chocolate comes from

Theobroma cacao seeds. Much of the chocolate consumed today is in the form of sweet chocolate, a combination of cocoa solids, cocoa butter or added vegetable oils, and sugar. Milk chocolate is sweet chocolate that additionally contains milk powder or condensed milk. White chocolate contains cocoa butter, sugar, and milk, but no cocoa solids.

5.4 Medical Uses

Natural News (2017), the world´s top news source on natural health reported cocoa to be a really good source of natural antioxidants. The antioxidant activity of cocoa is due to procyanidins and their monomeric precursors, epicatechin and catechin, which inhibit oxidation of LDL. Dark chocolate and cocoa inhibit LDL oxidation and increase high-density lipoprotein (HDL)-cholesterol concentrations. free radical scavengers that preserve cell membranes, protect DNA, prevent the oxidation of low-density lipoprotein (LDL) cholesterol that leads to atherosclerosis, and prevent plaque formation in arterial walls.

Natural News (2017) also talks about chocolates and how this one contains positive effects on mood, high blood pressure, and heart health, improving circulation and having no adverse effects on cholesterol. There are over 350 known chemicals found in chocolate, including stimulants like caffeine, theobromine, phenylethylamine and anandamide. Theobromine, the alkaloid contained in the beans, resembles caffeine in its action, but its effect on the central nervous system is less powerful and does not have the sleep disturbing effects of caffeine. Research published in the FASEB Journal in February 2005 makes a strong case that dark chocolate can be a powerful cough suppressant. The theobromine content of dark chocolate may actually be a more effective cough medicine than traditional or over-the counter cold and cough remedies. Phenylethylamine (PEA) facilitates the release of dopamine, this is the explanation for the "high" that you get from eating chocolate. The neurotransmitter anandamide, also found in chocolate is responsible for the prolonged pleasurable sensation of the previous mentioned PEA.

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