Paullinia cupana Kunth

Monograph Project

Agriculture class

2021-2022

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1.0 Introduction

Paullinia cupana is a fairly new plant: it was discovered in the 17th century, for reference: lemon was discovered in 200 AD, hence not many information is known about it. In this monograph all the information that could be researched has been collected. It normally propagates in Brazil. We will be talking about ecology, biology, production, propagation, market, and uses. It has all kinds of uses, such as supplements, recreative, and enhancers; it is becoming worldwide known and has a huge boost in the market.

2.0 Ecology

2.1 Affinities

Guaraná, known as *Paullinia cupana* Kunth, is a native species of the Brazilian Amazon, being also of great economic value. The guarana seed is known throughout the world due to its medicinal, stimulant, and energetic nature (García, 2005).

Paullinia cupana is a plant from the family Sapindaceae, which originated in the amazon. The seed is about a coffee bean size and it is a great stimulant since it contains twice the concentration of caffeine in the coffee seed (it has 3.5% more caffeine than coffee).

Kingdom: Plant
Division: Magnoliophyta
Class: Magnoliopsida
Order: Sapindales Family
Genus: Paullina Paullina Cupana
Species: Paullinia Cupana Kunth1823

Paulina Cuapana was discovered by Carl Sigismund Kunth, and it was published in Nova *Genera et Species Plantarum (quarto ed.)* (Bonpland, Humboldt and Kunth, 1815)

The authority for the species is Kunth, Karl (Carl) Sigismund. Due to its high amount of caffeine and tannins, the seed has medicinal and stimulating properties.

It belongs to the family Sapindaceae, which contains around 130 recognized genera (Trópicos, 2008), according to recent taxonomic revisions. Apart from that, it is recognized as a part of the sub-family Sapindoideae (Trópicos, 2008). Within this subfamily, Harrington et. Paullinia in the Paullinieae tribe was originally defined by Radlkofer in 1933.

Paulina cuapana grows in the Amazonian Forest (Figure 1, below) as said before is considered to be a plant, but more specifically is a liana, it has towering tree trunks that support the woody stem it produces. In the wilderness it can reach very high altitudes, under cultivation it is a different story. Guaraná under cultivation grows to be 2m tall with a diameter of 4m. The leaves of this plant have a smooth surface, also known as glabrous, the plant is evergreen. (Erickson,1984)

Figure 1: *Guaraná-producing regions of the Amazonas, with the greatest conservation on Maúes, Brazil (Erickson, 1984)*

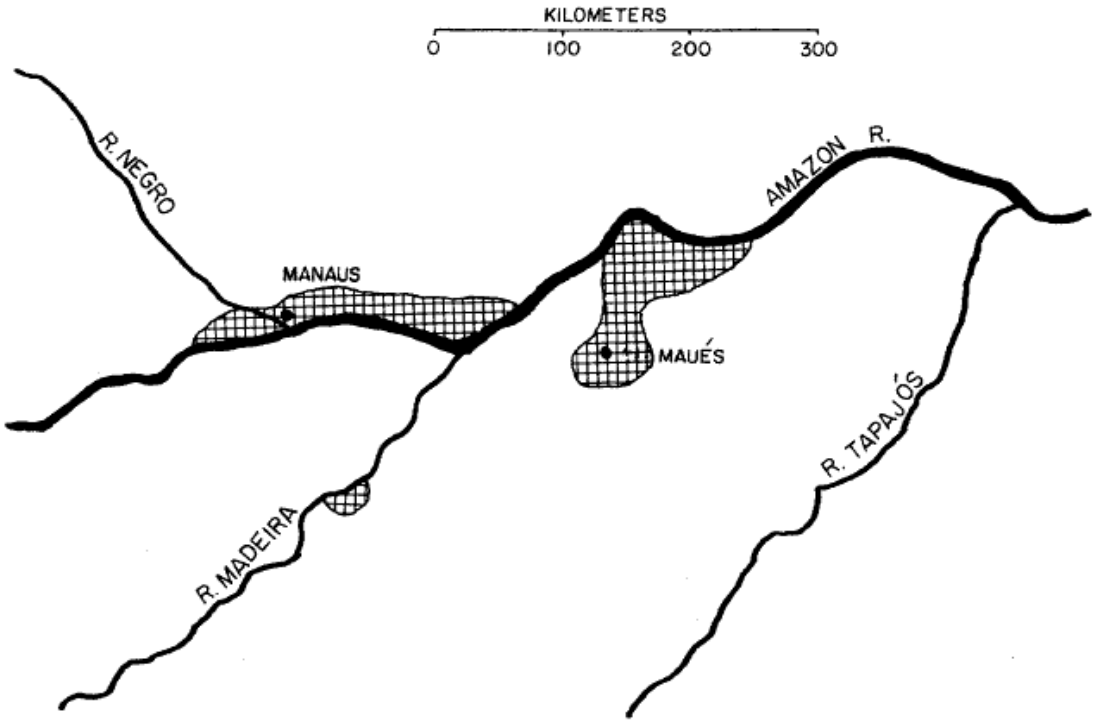
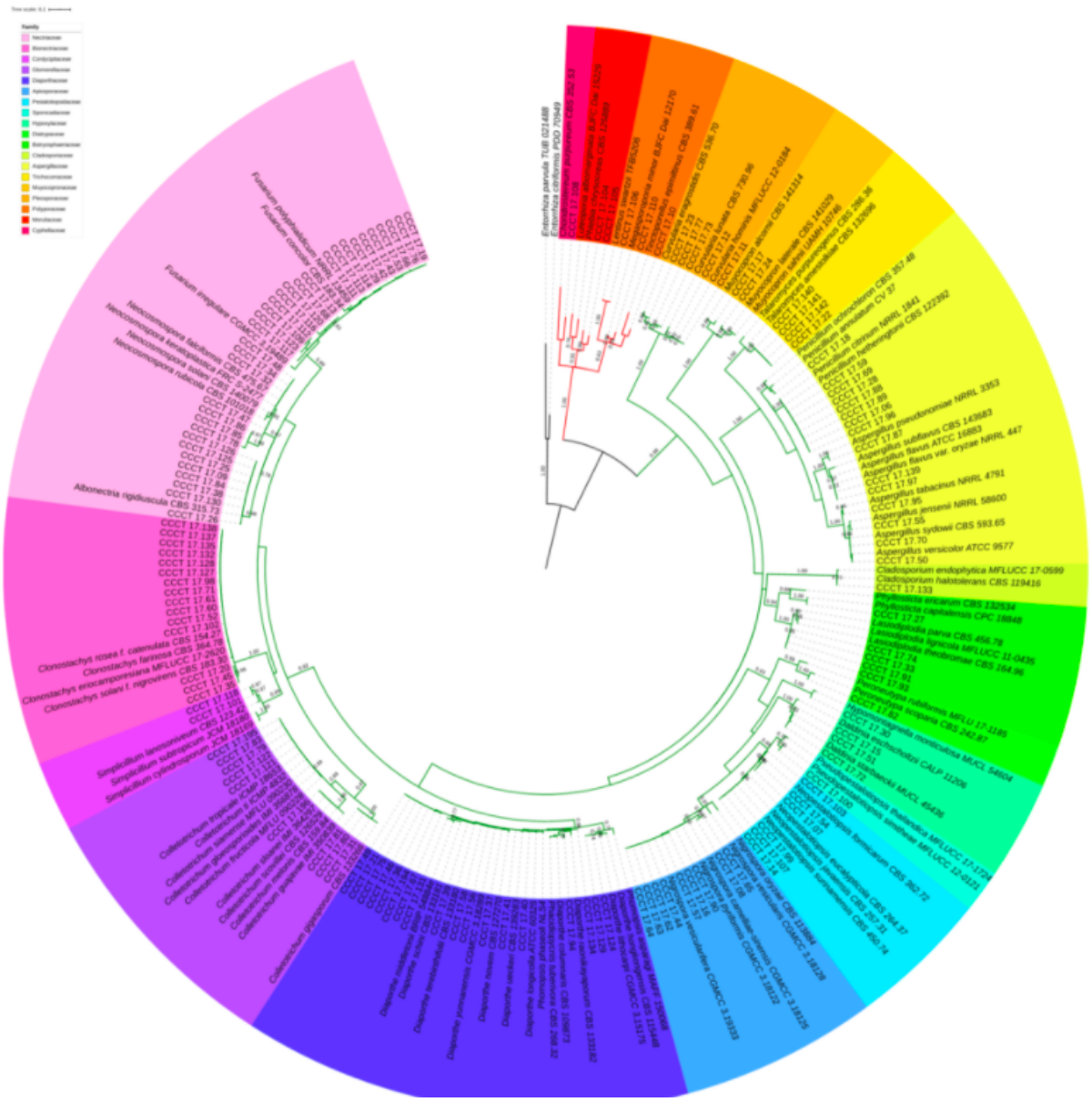


Figure 2: *A mature Guaraná plant in full flower (Pinheiro, 1984)*

Figure 3: *Phylogenetic tree for the belonging sequence of the 136 strains from guarana with other species detailed in Table S3. The color highlighted as red represents the branches composed of Basidiomycota species. The green highlight represents the Ascomycota species. (Santos et al., 2020)*



Note: to see this figure bigger open the hyperlink from the page: https://www.mdpi.com/2309-608X/6/3/123

Figure 4: *Guaraná seeds blossoming (Wikipedia, 2021)*

2.2 Fossil Record

There doesn't seem to be any fossil record for the Guarana Plant

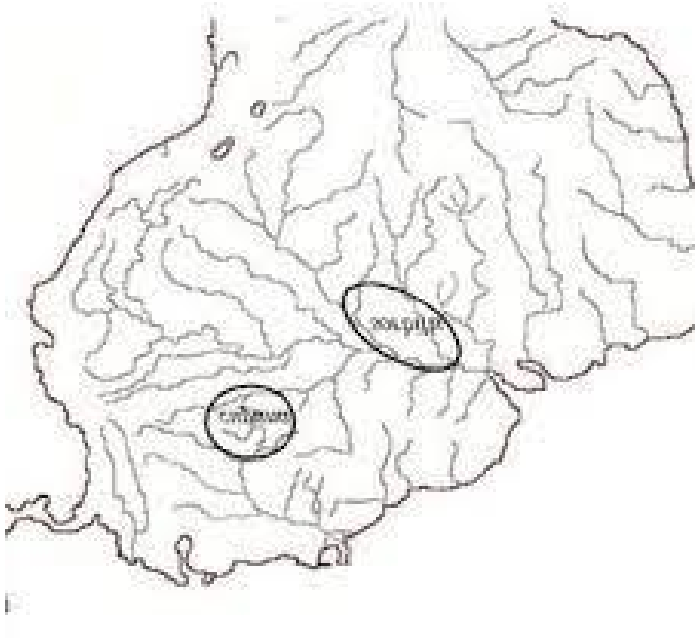
2.3 Present distribution

Figure 5: *The current countries producing Guaraná: Brazil North, Colombia, Ecuador, Guyana, Peru, Venezuela (Trópicos,2008).*

Paullinia cupana is currently distributed in tropical and subtropical South America, but it has a single species, P. pinnata, located in tropical Africa. A scientist, Radlkofer, in 1931 recognized 147 species of Guaraná in 13 different regions. The species *Paullinia cupana* was classified in the section Pleurotoechus, which has 28 species distributed from North America to South America, to be more specific, from Mexico to Rio de Janeiro; with 9 of these 28 species in the Amazon forest. To this day it turns out that there are 195 species that can be recognized as genus Paullinia (Tropicos, 2008) at least four of the divisions of Radlkofer, including Pleurotoechus, are still listed on theInternational Plant Names Index website (IPNI, 2008)

As said before, *Paullinia Cupana* was first classified by Kunth, it is well known that it originated in the south of the Atures and Maipures falls on the Orinoco river, and on the borders of Brazil, Venezuela, and Colombia.

Figure 6: *The first place of classification of Guaraná (Trópicos,2008).*



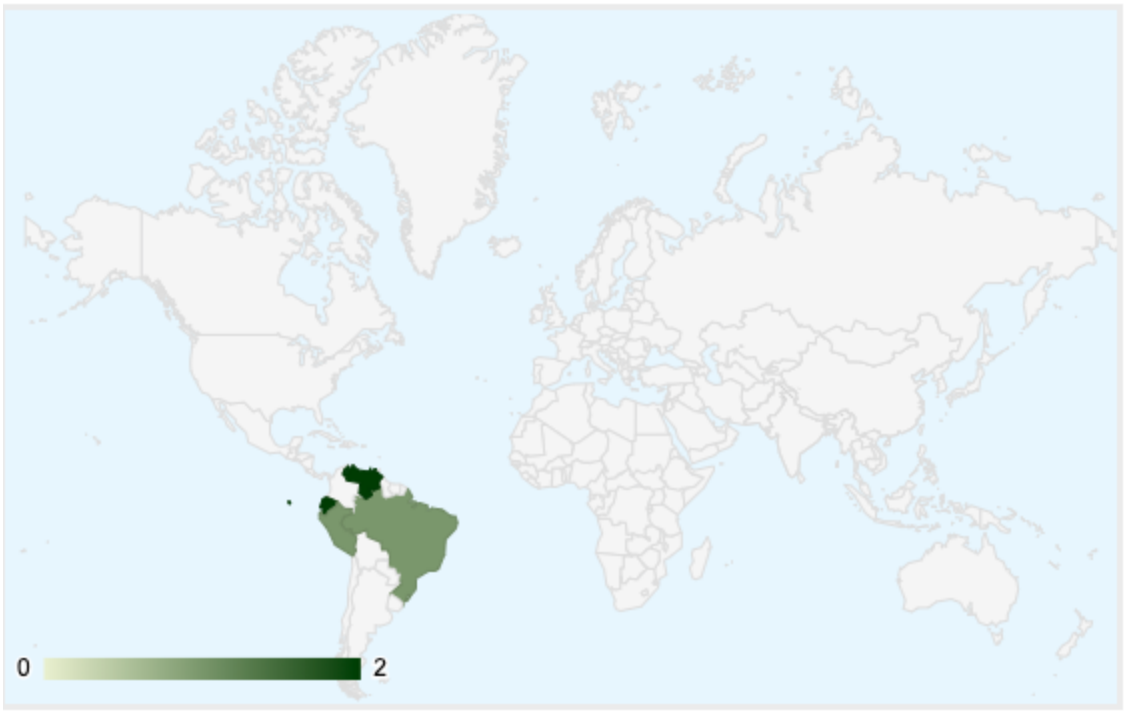
Twenty years later another scientist, Martius, was on a trip along the Amazon River, he collected botanical material and classified it as Paullinia sorbilis. This plant bloomed in Brazil, more specifically in the region Maúes. These two plants were classified as synonyms in 1938 (Ducke, 1938).

Figure 7: *Classification of Guaraná and its authors (zoom in to see clear, it couldn't be bigger) Adapted from (Tropicos, 2008)*

Continent	Country ↑	Upper	Lower	Author
South America	Brazil			Forzza, R. C.
South America	Ecuador			Renner, S. S., H. Balslev & L.B. Holm-Nielsen
South America	Ecuador	Napo		Jørgensen, P. M. & S. León-Yánez
South America	Ecuador	Napo		Renner, S. S., H. Balslev & L.B. Holm-Nielsen
South America	Peru			Macbride, J. F.
South America	Venezuela	Amazonas		Funk, V. A., T. H. Hollowell, P. E. Berry, C. L. Kelloff & S. Alexander
South America	Venezuela	Amazonas		Hokche, O., P. E. Berry & O. Huber

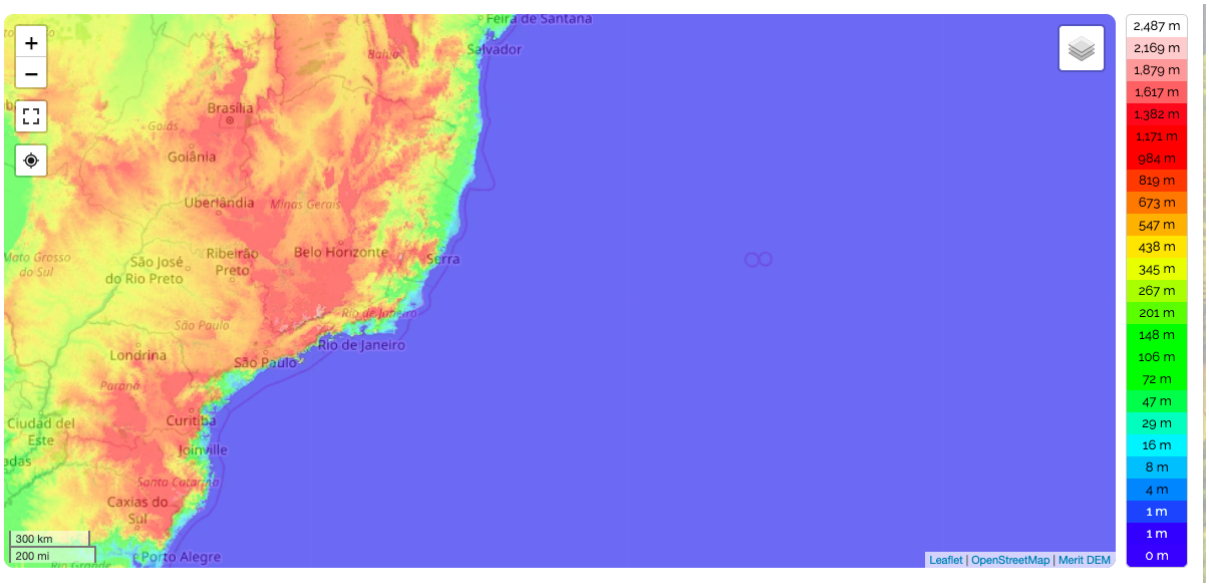
Page 1 of 1

Figure 8: *Distribution occurrence by country, Ecuador 2, Venezuela 2, Brasil 1, Peru 1 (Tropicos, 2008)*



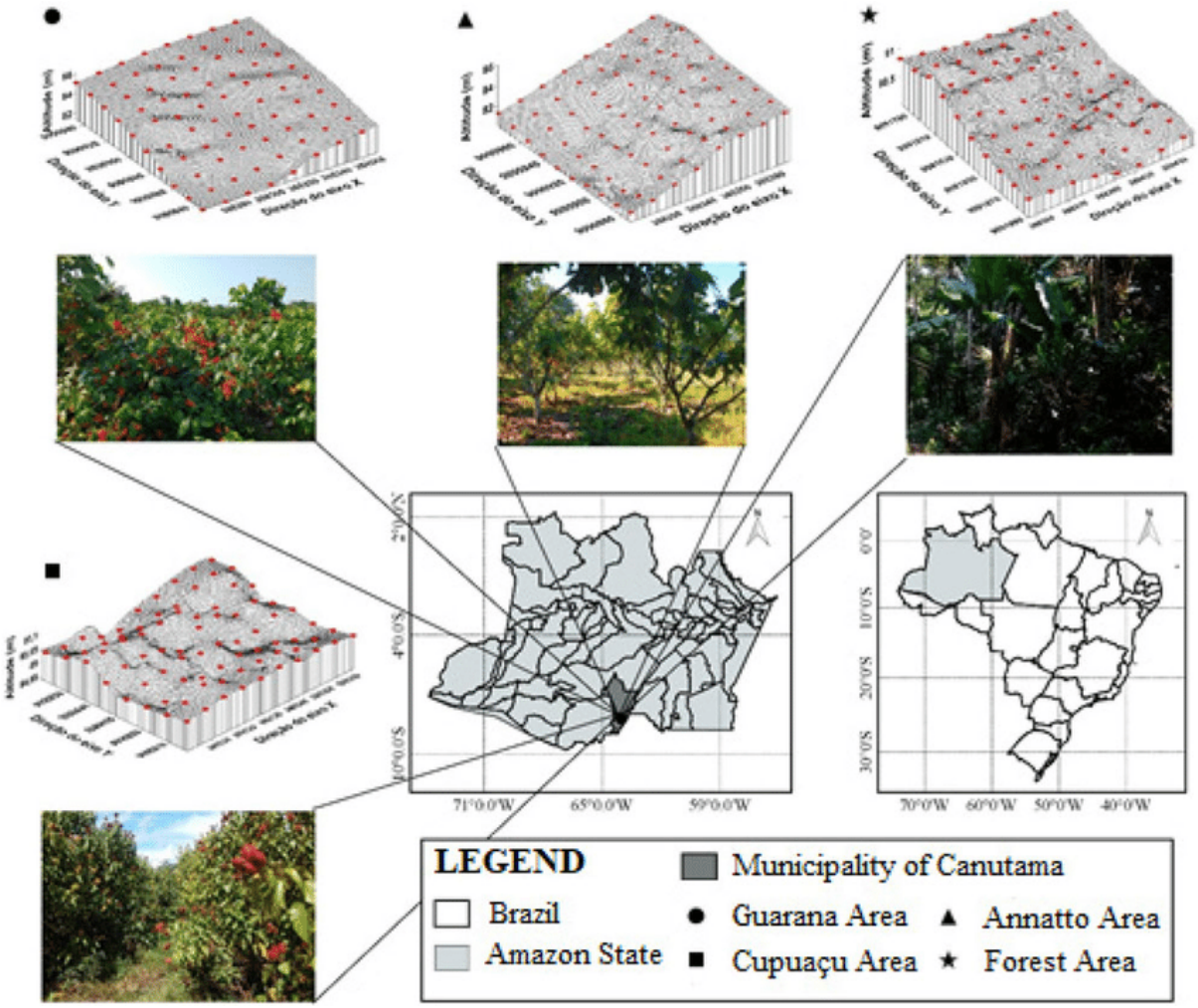
2.4 Elevation

Figure 9: *Guaraná, Aracruz, Linhares Microregion, Intermediate Geographic Region of São Mateus, Espírito Santo, Southeast Region, 29195-421, Brazil (-19,66867 -40,28092)*



This map is the Guaraná topographic map, elevation, relief. The coordinates that are presented are (-19,66867 -40,28092), with a minimum elevation of 8m and a maximum elevation of 458m, the average elevation of the plant is 83m (Topographic-Map, 2021)

Figure 10: *In an experiment conducted in November of 2012, Guaraná was planted in areas that were affected by wildfires. This plant was cultivated for 7 years and we learned that it had a slope of about 3%. There was no fertilization and liming during the whole growing period. Weed control and spraying were used to control these areas. (Souza, Fernando & Campos, Milton & Pinheiro, Elyenayra & Lima, Alan & Gomes de Brito Filho, Elilson & Cunha, José & Santos, Eduardo & Brito, Wildson, 2019).*



2.5 Climate

Guaraná grows in “terra frame”, which is a deep acid oxisol of the Amazonian forest, near the equator. This is a hot, humid region that has many dry seasons from the months of June to September. The temperature and rainfall can differ a lot in Manus (region of the Amazon), a 10-year table graph is shown in table 2:

TABLE 2. MONTHLY TEMPERATURE AND RAINFALL DATA FOR MANAUS, AMAZONAS, BRAZIL (10-YR AVERAGE, 1971–1981).[a]

Month	Rainfall mm	Temperature (°C)		
		Av maximum	Av minimum	Av
January	248	30.7	22.2	25.1
February	275	30.4	22.2	25.2
March	298	30.8	22.3	25.3
April	288	31.0	22.4	25.3
May	267	31.0	22.2	25.4
June	159	30.8	21.6	25.2
July	137	31.1	21.1	25.3
August	106	32.7	21.3	25.8
September	102	33.0	21.9	26.2
October	171	32.9	22.3	26.4
November	160	32.7	22.6	26.3
December	228	31.9	22.3	25.8
Year	2,439	31.6	22.0	25.6

[a] Bol. Agrometeorol., 1981. EMBRAPA UEPAE/Manaus.

(Erickson, 1984)

In modern times, the average rainfall varies between 2250 and 2750 mm per year, The rainy period is between October and June. The temperature in the region of growth, the Amazon, is between 25 and 27 degrees Celsius. The humidity in the air is about 85-90%. Souza, Fernando & Campos, Milton & Pinheiro, Elyenayra & Lima, Alan & Gomes de Brito Filho, Elilson & Cunha, José & Santos, Eduardo & Brito, Wildson, 2019).

Geology and Soils

The soil of the study conducted in 2019 was classified as RedYellow Argisol (Acrisols); this means that it has a high amount of iron content and a lot of oxidized ferric iron oxides. It is also defined by very weak depths, but it has very smooth slopes, and natural drainage is deficient (Souza et al, 2019). If we were to cultivate Guaraná the recommended stats are

Table 3: *Guaraná is normally harvested from September to December or January. It should bloom at an average yield of 500 G of dried seed per plant. (Erickson et al, 1984)*

Hardiness Zone	10
Bloom Season	Fall, Spring, Summer
Sun Requirement	Full Sun
Grows to	4-8'
Minimum Temperature Indoors	60

(Logees, 2021)

Origin

There is an Indian legend that explains the origin of Guaraná. The story says “A son born to a couple of Maué tribe, so the story goes, was an exceptional child who spread happiness and God will wherever he went, a veritable angel. A jealous evil spirit resolved to eliminate the youngster. Despite close supervision by the tribe, the child slipped out alone one day to collect fruit in the forest. The evil spirit, Iurupari, transformed himself into a snake that attacked and killed the child. When rescuers found him he was laying facing the sky, barring a benevolent expression in death, eyes open and wide.

Soon thereafter a shattering bolt of lightning shook the earth, hañting the lamentations of the assembled tribe. Enter the monster who gave a lengthy discourse on how she had received the divine instructions to bury the excised eyes of a child. No one wanted to accept the gruesome task so a lottery was conducted, and the internment was performed by the loser. Later a shrubby plant sprouted from the buried eyes. This was the first Guaraná and its origins account for ripe fruit having the appearance of living eyes”. (Monteiro 1965).

Although many stories are told and modified in different ways, what is clear is that the Guaraná figured in indigenous rituals and culture long before the arrival of the Europeans. Caucasians are said to have known the Guaraná products by 1775.

Community composition

The most recent information about the richness of this plant was in the year 2016. We can see the table below with the following information:

Table 4: We can see a table of production, and yield in guarana crops *(Palazzo, 2018)*

State	Planted area (ha)	Harvested area (ha)	Production (t)
Acre	6	4	2
Amazonas	8113	4912	855
Bahia	6500	6500	2600
Mato Grosso	353	317	180
Pará	92	24	12
Rondônia	92	91	37
Total	15,156	11,848	3686

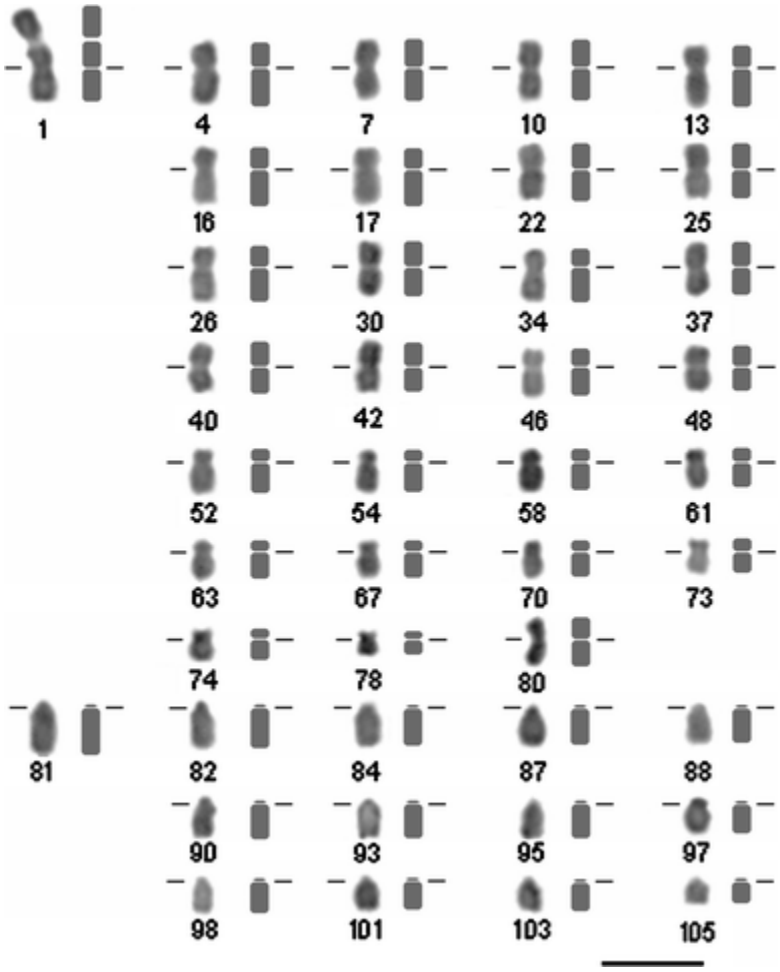
3.0 Biology

3.1 Chromosome complement

Paullinia cupana has two sets of 12 chromosomes, Cytological studies have shown that its family, Sapindaceae, has a wild diversity of chromosome complements ranging from two sets of 7- 48 chromosomes . To provide further detail, in the *Paullinia* genus seven species have been tested and have a chromosome complement of: 2n=24. The DNA content of this plant was determined by flow cytometry - a technique used to measure both physical and chemical characteristics of the amount of cells or particles within a plant. When the *Paullinia cupana Kunth* was studied, it was discovered that it has an elevated number of 2 sets of 105 chromosomes each (2n = 210) and that it can be distributed in two categories of cytomorphological groups: a. a metacentric (chromosome whose centromere is centrally located in a constricted region of a chromosome that separates it into a short arm (p) and a long arm (q)) (Online, 2021) and submetacentric group showing 25 sets of three pairs of chromosomes (2-76), and b, a group containing only acrocentric (a chromosome in which the centromere is located quite near one end of the chromosome) (Net, 2021) (showing 12 sets of two pairs of chromosomes (82-105), a homologous submetacentric pair (1) and an acrocentric pair (81) Figure 12 below. The mean of all of these results determined that the DNA content of Guaraná was 2 sets of 22.8 chromosomes (2C = 22.8 pg) (de Freitas et al., 2007).:

Figure 11:

Karyotype with 210 chromosomes in guaraná (Paullinia cupana ‘Sorbilis’)



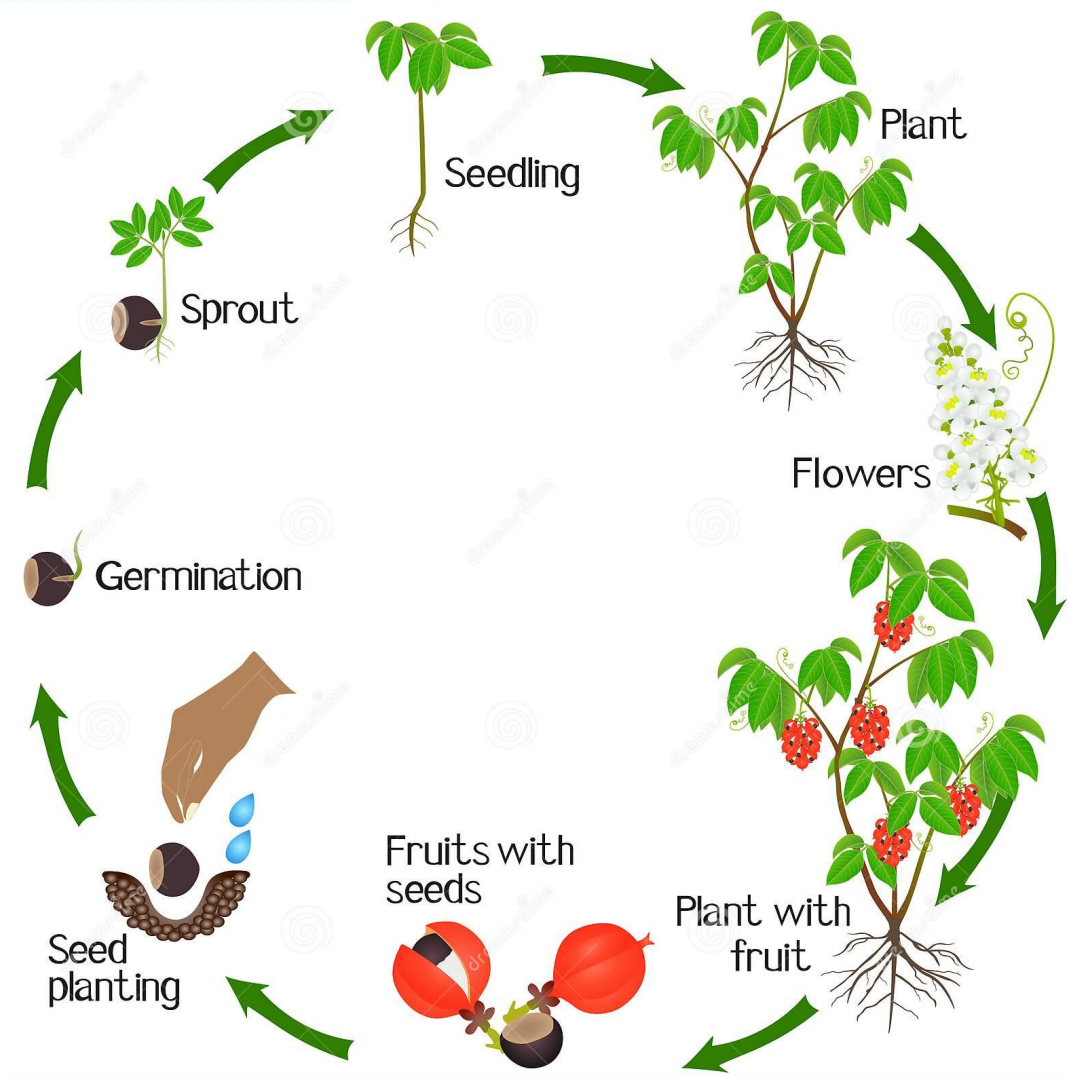
de Freitas, D.V., Carvalho, C.R., Filho, F.J.d.N. *et al.* Karyotype with 210 chromosomes in guaraná (*Paullinia cupana* ‘Sorbilis’). *J Plant Res* 120, 399 (2007). https://doi.org/10.1007/s10265-007-0073-4

3.2 Life Cycle

The basic diagram of the Guarana life cycle is shown in Figure 13 below:

Figure 12:

Paullinia Cupana life cycle:



(*Life Cycle Of Guarana Plant On A White Background. Stock Vector - Illustration of Edible, Crop*, n.d.)

pes in commercial production. The work, therefore, aims to obtain a so-called plant ideotype (Bueno et al., 2001). The following objectives were set for

the breeding program coordinated by Embrapa Amazônia Occidental: to select guarana clones with a yield greater than 1.0 kg of seeds per plant, wide adaptability, good stability, tolerance to the main diseases (anthracnosis and super-shooting disease: Figure 17.7), with improved fruit quality (higher caffeine content), resistance to pre-harvest fruit drop and more uniform maturation (Nascimento Filho and Atroch, 2002).

Seed productivity is the most important selection criterion. The minimum period for evaluating productivity is five years (Nascimento Filho, 2003; Atroch,

2004). Other variables help in deciding which are the best genotypes, such as main branch length, number of branches, and number of leaves, indicating the plants' ability to establish themselves and survive after planting in the field (Nascimento Filho and Atroch, 2002). Adaptability and production stability are measured by the average productivity of genotypes in a variety of environmental conditions, cropping systems, locations, as well as year-on-year variations (Nascimento Filho and Atroch, 2002).

The plant is generally evaluated for anthracnosis twice a year, in the dry season (September-October) and the rainy season (March-May), using a scale from 0 to 3. Zero indicates the absence of the disease. Genotypes rated 2 and 3 are discarded during the selection process. For super-shooting disease, the percentage of infected branches is measured and the severity of the disease is also evaluated on a scale from 0 to 3 (Nascimento Filho and Atroch, 2002).

One problem observed in guarana plantations is the significant lack of uniformity in the harvest. A plant is harvested ten to twenty times during the harvest period (October to December). However, using hormones to render the harvest uniform would not be economically viable, and would lead to market rejection, given the stringent requirements for chemical residues on crops. To overcome this problem, the number of harvests has been treated as a selection variable since 2000. This means that a genotype that requires a greater number of collections can be selected for small farmers with the required labor force. For large producers with limited labor and storage facilities, genotypes with a lower number of collections per harvest can be selected (Nascimento Filho and Atroch, 2002).

3.3 Phenology

In this species Inflorescences are borne on new wood. Growth occurs much faster and earlier in the rainy season, the plan is already semi-hard when flowers begin to develop. But, growth can simultaneously occur when the floral development is taking place, it just takes place in a new branch. These branches are soft and succulent during flowering. Each blossoming flower is composed of several hundred undeveloped parts of the plant clustered in small groups on racemes up to 30 cm long. Since this flower is unisexual (more about this in the sexuality chapter) it brings up one of the most engaging features of the plant. All already developed and open flowers, and all blossoming flowers on a branch, will be of the same sex on any given day.

However, in other branches, the plant can have anthesis of the opposite sex. A developing flower will have waves of flower production, which can extend over a month or more. Each wave will be exclusively pistillate or staminate. Although it is very rare to see pistillate flowers, this is one-sixth of the total (Schultz and Valois, 1974). They contain staminodium (sterile stamen) that fails to develop. Not all flowering happens in the same month, this can take about a year and it appears depending on the rainfall patterns. If rains persist and the dry season is tardy, flowering might be delayed until September; it normally occurs in July, peaking in August or early September. (Erickson et al., 1984.)

Figure 13:

Male (A) and Female (B) Guarana Flowers. Megalopta..., n.d.)

(Krug et al., 2018) In picture (C) it can be evident how a bee is polininzing a guarana plant. Picture (D) is the cultivation of guarana spread through a specific terrain. Finally, in picture (E) it can be seen in more depth the germination of the guarana seeds.

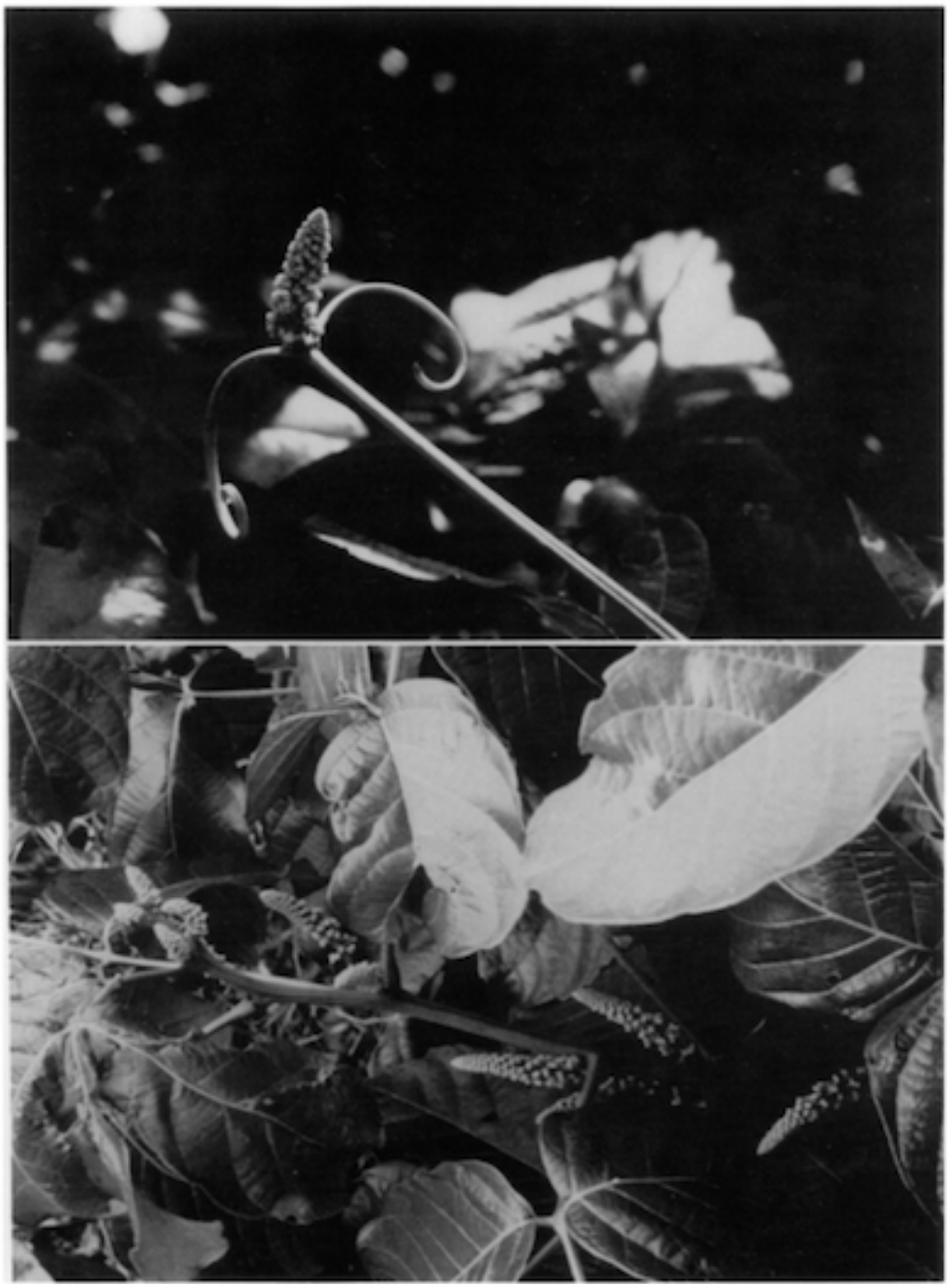
A very interesting anecdote is something that occurred in 1983. This year, the opposite occurred. Rains didn't come on the precipitated time and numerous plants began blooming in March, which is decidedly off-season. Fruit ripening would occur in the driest period of the year, leading to a lot of crop loss. (Erickson et al., 1984)

3.4 Sexuality

Paullinia cupana is known to have monoecious sexuality. As already mentioned before it's basically a unisexual plant, this is because it has both stamens and the pistils in separate flowers

on the same plant. It can be compared to biology, where a body is both born with male and female organs. In the guarana flowers the individual small, off-white flowers are unisexual although inflorescences include both staminate and pistillate flowers. Something to keep in mind is that either pistillate or staminate flowers are produced on a certain day. (Krug et al., 2015) Visible in the image below:

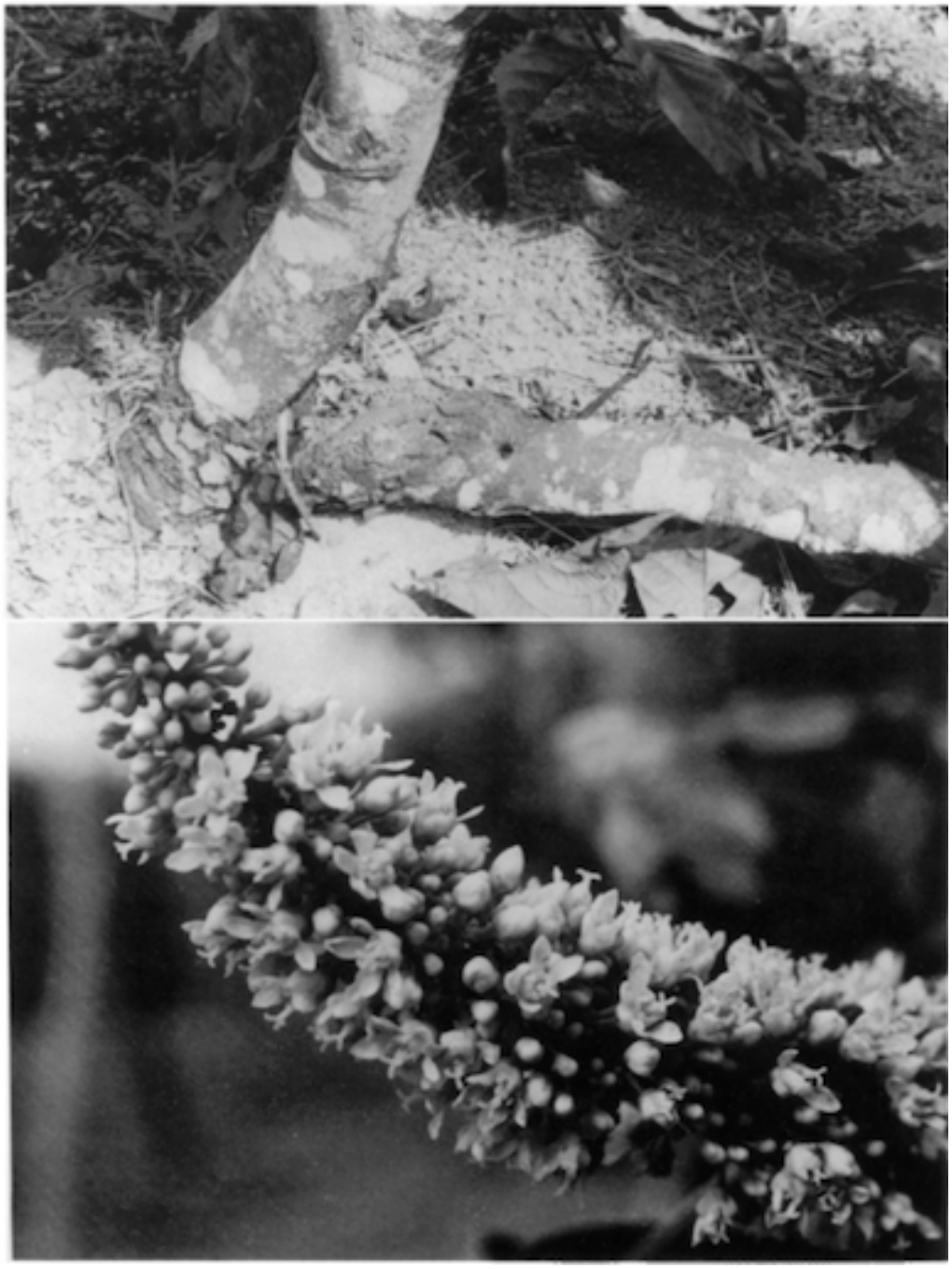
Figure 14:
Developing inflorescences on a typical fruiting branch (below) and as inflorescences arising from tendril



(Erickson et al., 1984.)

Figure 15:

The divided trunk of the guarana plant. Pistillate flowers



(Erickson et al.,1984.)

3.5 Pollen, Pollination, and Potential Pollinators

Continuous researchers have found that pollination is by insects, primarily bees and wasps. There can also be evidence of ants along with the plant, where they continuously move along the branches. An interesting detail has been found and it is that guarana flowers open in the

early morning. Most pollen has disappeared by midday, this is because pistillate flowers seem to be receptive for one day only. (Erickson et al.,1984.). There was a study performed in 2015 by Krug et al, where they determined at what time was the guarana plant most pollen. Their studies showed that the guarana plant emits a strong scent and that it has most pollen at night; the research took place in two Brazilian regions: Maues and Manaus (Krug et al., 2015). The table below shows the data:

Table 6:

Number of Megalopta individuals attracted to different scent mixtures in field bioassays performed in Manaus and Maués:

	Day-scent 1	Day-scent 2*		Night-scent*
Bees	**Maués** ***N* = 9**	**Manaus** ***N* = 9**	**Maués** ***N* = 3**	**Manaus** ***N* = 8**
Megalopta aeineicollis		9		16
Megalopta cuprea		1		
Megalopta piraha				1
Megalopta sodalis				1
Megalopta sp.	3		2	

N= number of trials

(Krug et al., 2015)

Furthermore, In this other image:

Figure 16:

Nocturnal bee pollination the guarana plant

(Erickson et al.,1984.)

We can conclude that it depends on cross-pollination to set fruits, with diurnal bees traditionally cited as the main pollinators (Krug et al., 2015)

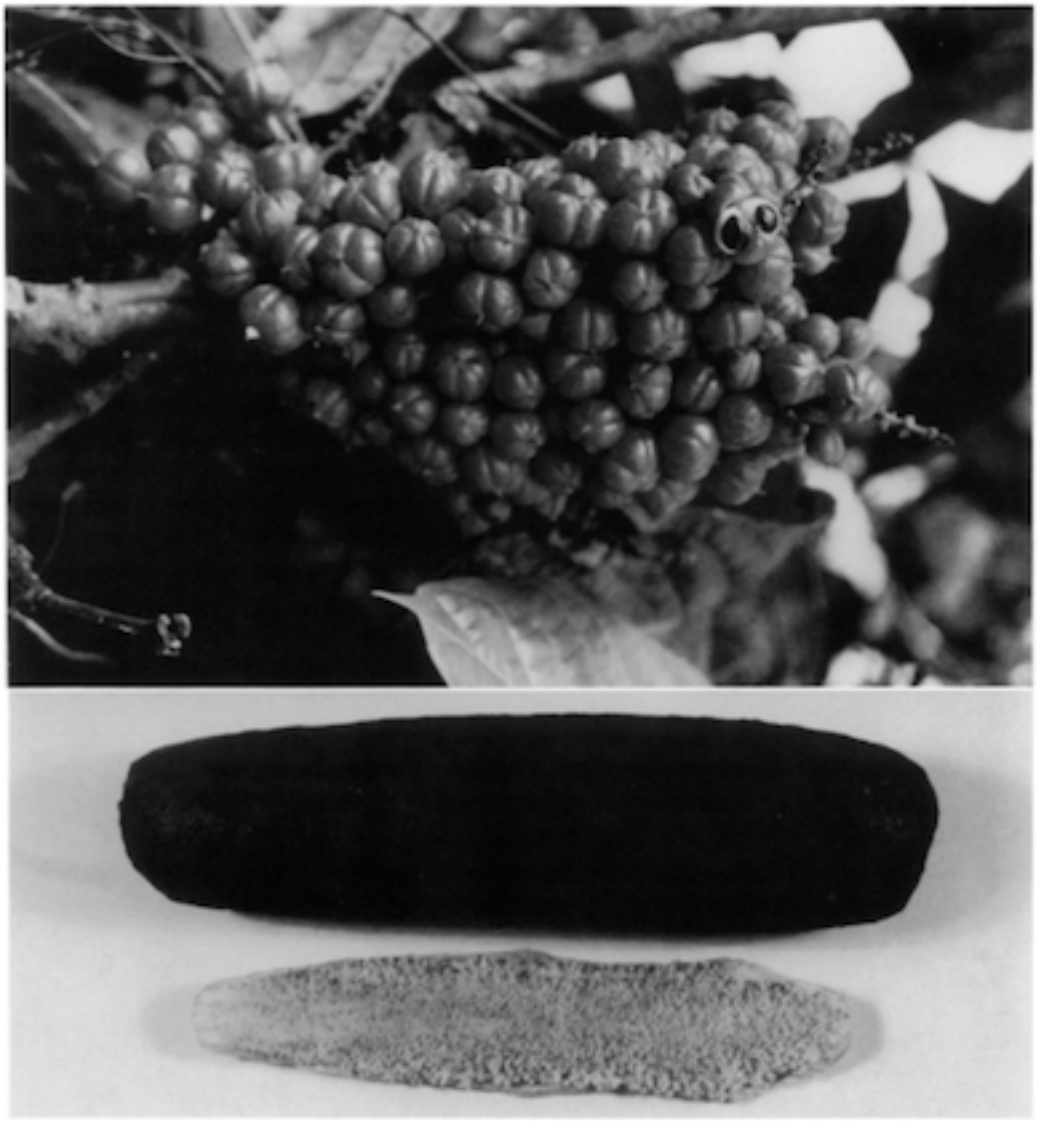
3.6 Fruit Development and Seed Set

A single blooming flower can produce several dozen fruits in different stages of
Its development (Fig- 19, below). Seeds are composed of 2 embryonic leaves, known as cotyledons surrounded by a thin, woody coat. Germination is underground and it takes around 1-3 months. Seeds (Fig-20) lose most of their scent and price if it's allowed to dry out. Young plants have unifoliate leaves and after about the 6-10th leaf a blossomed plant germinated at the compound level. When there is an atrocious space to grow, seeding can take up to one per month.

This causes the blossoming, immature states to last for a year. Some plants flower when I½ yr old, but 3-4 yr are required for commercially significant production (Erickson et al.,1984.)

Figure 17:

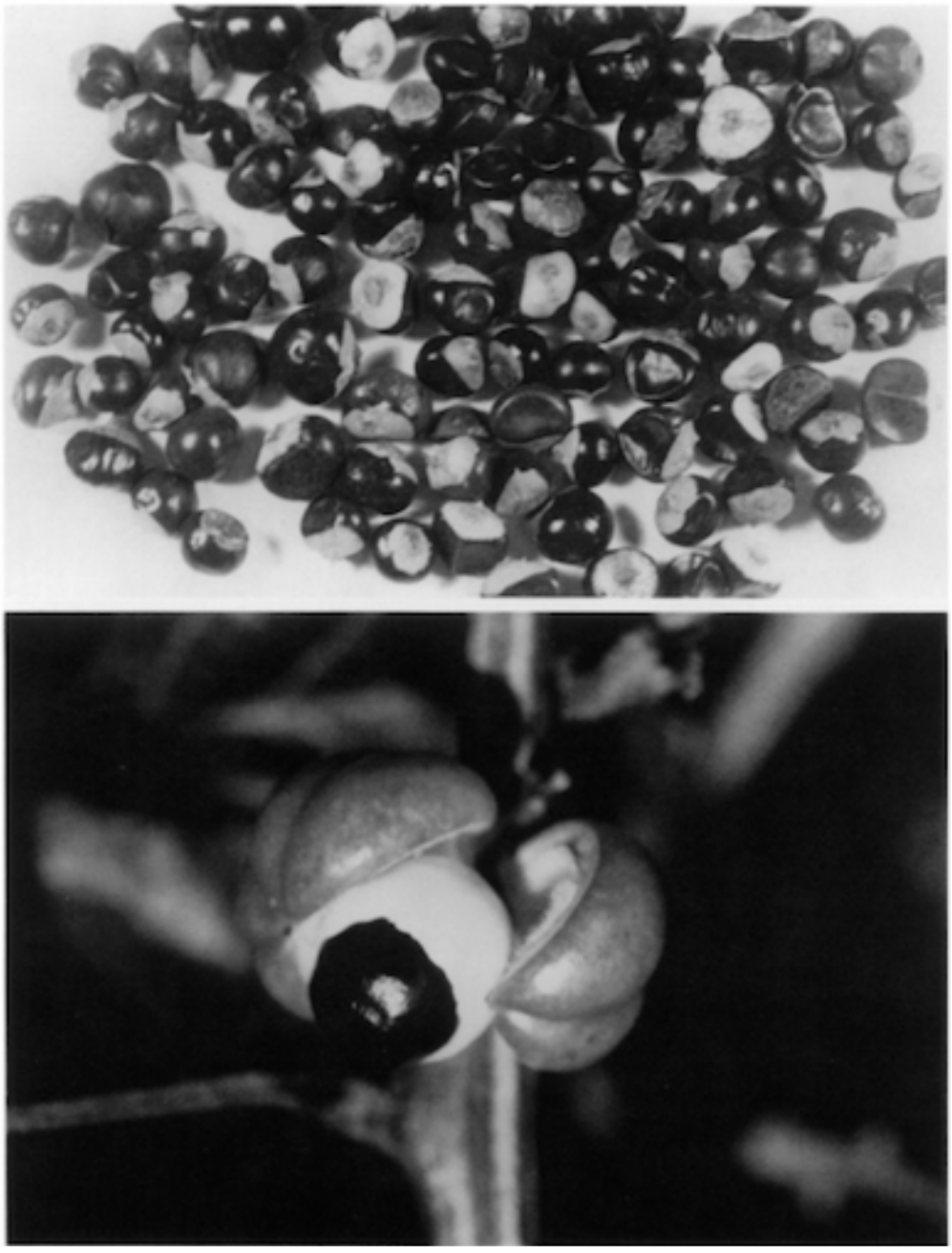
A nearly matured guarana fruit



(Erickson et al.,1984.)

Figure 18:

A matured guarana seed



(Erickson et al., 1984.)

4.0 Production and Propagation

4.1 Natural Regeneration:

Whilst there isn't much information on how it grows naturally, we can connect it to the phenology of our plant in chapter 3

4.2 Nursery Propagation:

This plantation is typically grown on land newly cleared on the forest where nothing else has been cultivated before. These plants grow from seeds that have been moist in sawdust before cultivation. Germination takes place over a period lasting 1-3 months. As soon seeding blooms they are placed in solid filled, 1-liter containers which are made of black plastic film. Then, they are kept in a dark place that has a lot of shade for almost a year so they can be translated into field planting. They are almost always planted in January and February, science this is the rainy season. The cultivation of the plant is arranged in a 4m x 4m square and has an approximation of 625 plants/ha. If it's done by 3m x 3m there would be 1,100 plants/ha. (Erickson et al, 1984)

Figure 19: *Guaranáplants in a nursery, before being planted in a field. ((H. T. Erickson, Maria Pinheiro F. Corrêa, & José Ricardo Escobar, 1984).*

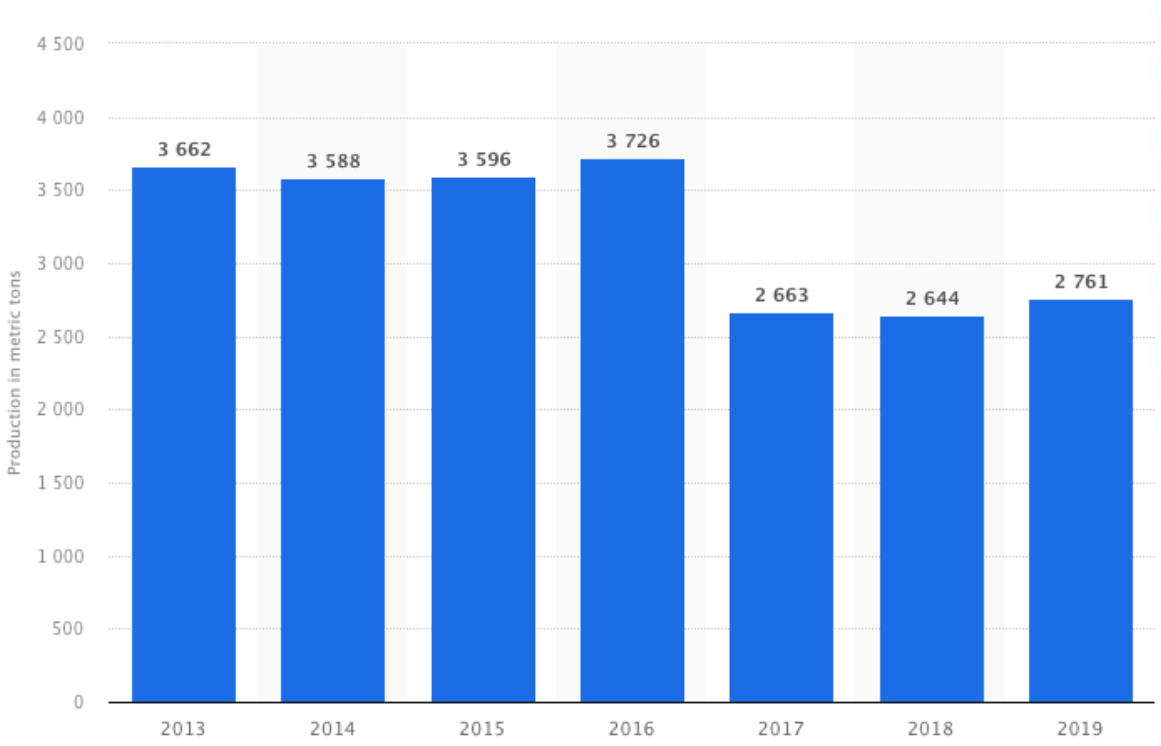
Table 4: *This shows the seed production for Guaraná over the past 5 years in Brazil((H. T. Erickson, Maria Pinheiro F. Corrêa, & José Ricardo Escobar, 1984).*

Plant selection no.	Production (kg)					
	1976	1977	1978	1979	1980	Av
35	9.1	2.3	2.6	5.7	2.5	4.4
21	8.2	3.8	3.2	3.5	2.9	4.3
05	6.8	1.3	2.8	1.8	1.3	2.8
15	1.8	3.7	0.5	2.7	1.4	2.0
13	4.7	2.5	0.8	0.5	1.4	2.0
20	7.9	1.4	0.0	0.4	0.0	1.9
01	2.5	0.3	1.5	0.7	0.9	1.2
03	2.4	0.0	0.8	0.6	0.7	0.9
18	2.0	0.3	0.5	0.0	1.0	0.8
Average	5.0	1.7	1.4	1.7	1.3	2.2

[a] Corrêa and Escobar, 1981.

Table 5:

Guaraná production from 2013-19 in Brazil (Statista, 2019)



4.2.1 Vegetative Propagation:

As explained in chapter 3, our plant is asexually reproduced, but in order to propagate the plant yourself you need to acquire a Guarana seed and plant it. The conditions of the planting can be read in section 4.3 below this one.

Another thing that is known to work, due to the reproduction of *Paullinia cupana,* is that you can acquire two branches from this plant, you split them in half and tie each of them together and it will grow. This could also work with branches, leaves or roots, because when they are placed in the right environment it forms new roots and branches, thus producing a new plant. (Luchessi & Rodrigues, 1978)

Figure 20: Growth of a green apple tree after tying two branches together *(Katie, 2021)*

4.3 Propagation and Planting:

The major step when planting this plant is the acquiring of the seeds. Because of its rarity, most guarana seeds are viable only for 72 hours, if you didn't have the chance to get a pack of seeds you have to wait for at least 100 days until they are available again. After acquiring the seeds, you are ready to plant! But there are some important things you have to learn first. The seeds need to be sown 1/2 inches deep; the soil must maintain moistness, and it is important that the climate is warm and humid with a minimum temperature of around 20 ° C. (Garden Web, 2019)

Requirements for Growing Guarana

Watering

1. Water the guarana plant every morning before the sun hits the leaves, it is crucial that the plant stays moist

Soil

1. Soil acidity pH level should be 4.5. Light, loamy soil is recommended

Pruning

1. Eliminate old, damaged, diseased, and dead branches so they can bloom

Growing Guarana

1. Always soak your seed in water 24 hours prior to planting

2. When planting in a pot use regular planting soil and poke two or three holes (half-inch deep) into the soil of each pot. Drop one of the soaked seeds into each hole and cover it with soil

3. When they germinate (2-3 inches tall) make sure to move the seed into an open field.

4. Keep the same soil acidity mentioned before. Fertilize with hydrochloric acid to keep the soil acidic every other month.

   (Garden Web, 2019)

Table 5: Important information when planting *(UrbanTropicals, 2020)*

OUTDOOR	PATIO
Zone 10a-11	Zone 4a-11

SOIL TYPE	% SUN
Rich Moist	80-100%

POT SIZE	INCLUDES
2x2x7″ Deep	One Plant

4.4 Management:

Container:

The first initial pot you should acquire should have the measurements of an 8″ to a 20″ diameter, 14″ deep container will suffice. The looser the roots the healthier they will grow, that is why, if you have the possibilities you should plant them in an open space outdoors. Keep in mind that it should always be translated to a larger pot (UrbanTropicals, 2020)

4.5 Fertilizer

The best way to fertilize is in small quantities 10 inches away from the base, 3 times a year with a slow time release product. With unfertilized soil, the seed will grow slower, and if it is a cheap fertilizer, the heavy salt it contains will damage the roots and possibly kill the plant. (UrbanTropicals, 2020)

4.6 Grow zone

The best place to grow the Guarana Bush is outdoors since it requires 80-100% sunlight; in the winter it is better to bring the Bush indoors or protected. The *Paullinia cupana* bush will germinate in the summer.(UrbanTropicals, 2020)

Before transitioning to an open field When they are being grown at the nursery make sure the bush is grown under 20-40% shade cloth because if it's too light leaf burn could happen. When it is time to move the plant to the open field the best thing that could be done is to start with a little shadow and start moving it slowly to a sunny area over the week. (UrbanTropicals, 2020)

4.7 Tending

Since the adequate environment for the Guarana tree is a tropical rain forest it is hard in some places to maintain it. That is why in Brazil, Colombia, and Venezuela the production is so high because they have that environment already. In the United States, Guarana can grow in semi-tropical states such as Florida, the Hawaiian Islands, Puerto Rico, and the US Virgin Islands. But, if you don't have this climate you have to biografía a greenhouse or sunspace with a high ceiling so that it creates humidity. (Purdue University, 2019)

5.0 Market and uses

5.1 Markets

Guarana has many different forms, it has a lot of benefits and it is becoming extensively used. The *European Medicines Agency* recommends an adult take 450 mg in powder form five times a day. It should not exceed three grams per day.

Capsules: Recommended to take 2 capsules every morning

Infusions: These are done to boost someone's energy, it is recommended to only take one, max two per day since guarana has 3.5% more caffeine than coffee.

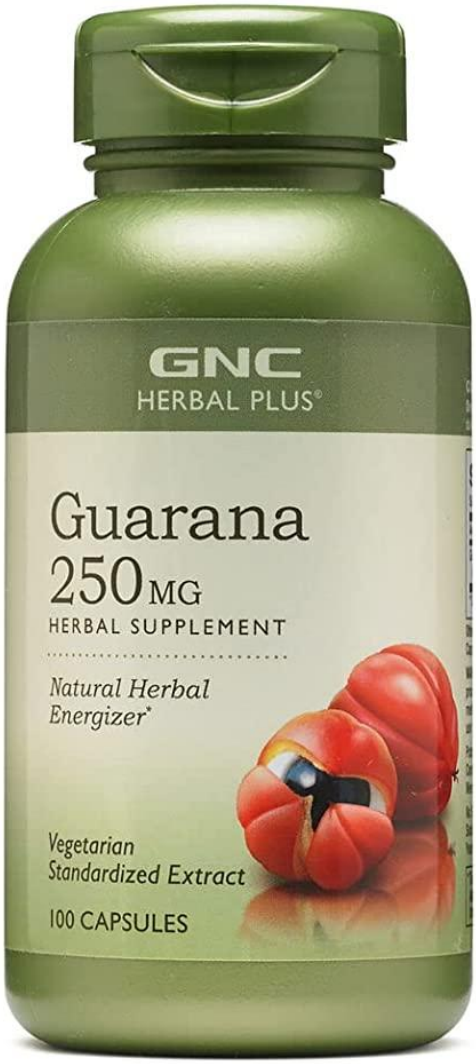
Ampoules: It is used as a food supplement, recommended use is once a day

Sticks: Liquid sticks are used to remove cellulitis and work as a fat burner, once every night is a perfect use.

(Pérez, 2022)

Figure 21:

Guarana capsules sold on *Amazon (Amazon, 2022)*



Guarana is getting widely recognized, in the market, they have surpassed USD 120 Million, in 2019 it was estimated it would grow 7% over a compound annual growth rate between 2020 and 2026. It is said that the guarana market has increased significantly consumer health awareness along with the need for organic products (Global Market insights, 2019)

Table 6:

Guarana market estimate troufth the following years *(Global Market insights, 2019)*

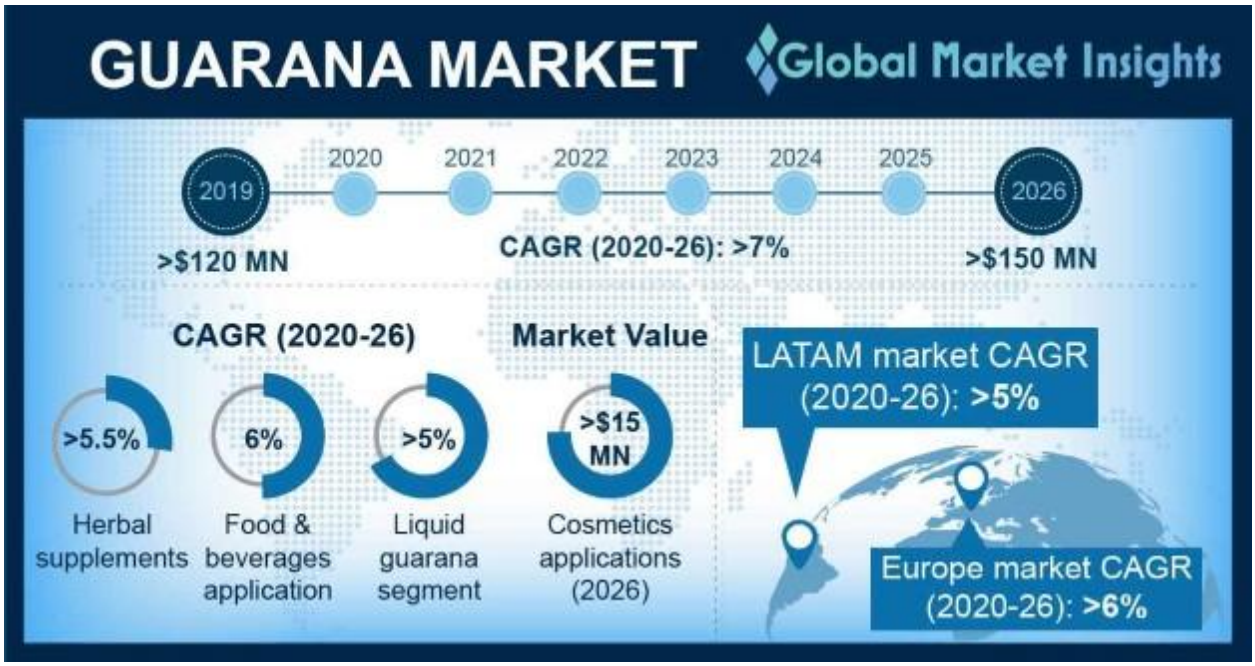


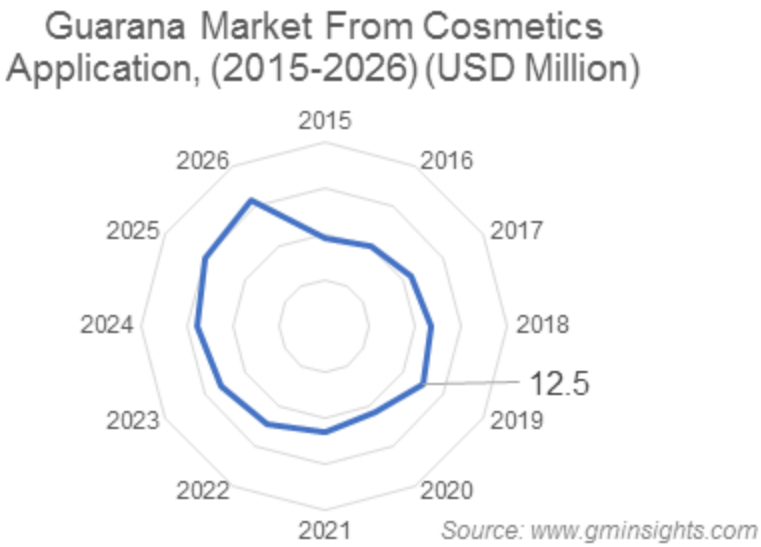
Table 7:

Guarana Market Report Coverage in 2019 *(Global Market insights, 2019)*

Report Coverage	Details
Base Year:	2019
Market Size in 2019:	122.56 Million (USD)
Forecast Period:	2020 to 2026
Forecast Period 2020 to 2026 CAGR:	5.8%
2026 Value Projection:	161.65 Million (USD)
Historical Data for:	2015 to 2019
No. of Pages:	70
Tables, Charts & Figures:	83
Segments covered:	Application, Form
Growth Drivers:	• North America: Rising demand for dietary supplements • Europe: Growing beverage industry • APAC: Product incorporation in pharmaceuticals • LATAM: Product consumption in food & beverage sector • MEA: Strong product demand from health supplements market
Pitfalls & Challenges:	• Supply chain disruptions due to concentrated production in Latin America

Table 8:

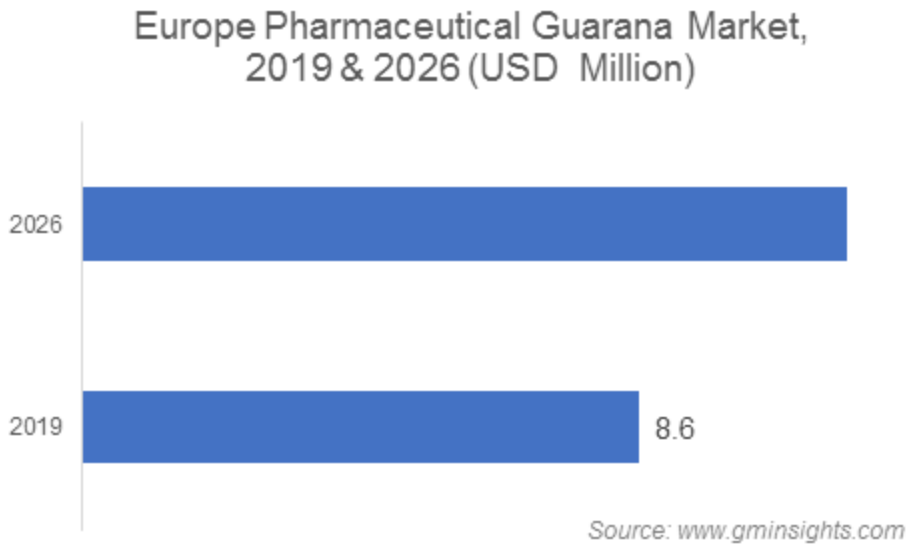
Booming cosmetics products demand owing to strong skincare market



By 2026 it is estimated that Guarana market-based cosmetics will reach over USD 15 million. The seed of the Guarana has a lot of use since it is used in cosmetic products, cleansers, makeup, facemask, anti-aging creams, and moisturizer lotions. This is because the seed contains antioxidant and antimicrobial properties, which are scientifically proven that it helps reduce skin impurities by boosting blood flow. This makes the seed very demanded in the market. (Global Market insights, 2019)

Table 9:

Growing pharmaceutical industry in Europe *(Global Market insights, 2019)*



Guarana is expected to surpass USD 150 Million by 2026, according to Global Market Insights, Inc.

According to the professional Casas "Guarana seeds contain vitamins A, B, E calcium, phosphorus, magnesium, and iron. Therefore, it is a great nutrient with numerous therapeutic benefits recognized for decades." (Casas, 2021)

5.2 Uses

Guarana can be used as a supplement, the seed is roasted and crushed, forming a brown powder is obtained, which is rich in caffeine and tannins (a group of bitter and astringent compounds that have anti-inflammatory properties), Axa Health Keeper says that "the energy drink industry uses 70% of the guarana produced and the remaining 30% is converted into powder." (Axa Health Keeper, 2019)

MedlinePlus experts say that guarana can be used to treat obesity and increase athletic performance

Guarana releases adrenaline, stimulating the central nervous system, making its consumption have many benefits:

- Powerful energizer: According to the European Food Safety Authority, the effects of caffeine can begin within 15 to 30 minutes of consuming it, lasting lots of time.

- Improves fat: high caffeine can increase metabolism by 3 to 11%, allowing you to burn calories faster, helping the burn off excess fat finalizing in weight loss.

- Antioxidant properties: This property removes wrinkles and can prevent them because of the anti-cellular aging. It can also help improve cardiovascular diseases and diabetes.

(Casas, 2021)

Contraindications of guarana

Because of the high caffeine levels it has many downfalls:

- Anxiety and nervousness.

- Gastritis

- Tachycardia

- High blood pressure.

- Headache.

(Casas, 2021)

It can cause a premature abortion for pregnant women

Before consuming it is best to talk to a professional

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