

The Geisha coffee variety and its status in the world and in Mexico

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Abstract

The Geisha coffee variety belongs to the species *Coffea arabica*; L.1753; it has the potential to replace traditional varieties due to its partial resistance to rust and high cup quality. Although information about it is scattered, this work reviews and compiles its morphological, productive, environmental, and historical characteristics and current situation in the world and in Mexico. Information search included scientific papers, books, and digital theses available online. As a result, it was found that Geisha, native to Ethiopia, has S-shaped branches, reaches over 3 m in height and faces threats such as the coffee berry borer (*Hypothenemus hampei* Ferrari 1867), the leaf miner (*Leucoptera coffeella*; Guérin-Méneville and Perrrottet, 1842), and the root mealybug (*Planococcus lilacinus*; Cockerell, 1905). Its partial resistance to rust, thanks to the SH1 and SH5 genes, gives it advantages against coffee rust (*Hemileia vastatrix*; Berkeley and Broome, 1869). Recognized for its exceptional quality (95.25/100), it has reached prices of up to 1 029 dollars per pound, generating global interest. In conclusion, Geisha arrived in Mexico in 1980 through the Mexican Coffee Institute; however, its production in the country is limited, with presence in certified farms and for local consumption. This review fulfils the objective of highlighting its characteristics in Mexico and in other parts of the world.

Keywords:

Coffea arabica, *Hemileia vastatrix*, cup quality.



In Mexico, coffee growing represents a high economic, social and environmental value due to the generation of foreign exchange and jobs; it is considered the livelihood of small producers and around 30 indigenous groups (CERDSSA, 2018). This activity is carried out mainly on the slopes of the mountain range in the center and south of the country; the main coffee-producing states are: Colima, Chiapas, Guerrero, Hidalgo, Jalisco, Nayarit, Oaxaca, Puebla, Querétaro, San Luis Potosí, Tabasco and Veracruz (SADER, 2019).

Of the total production, 84% are Arabica beans processed with wet processing, 12% are natural Arabica beans (dried in the sun, without pulping the cherry), and 4% corresponds to the robusta variety (Palomares *et al.*, 2012). Nonetheless, one of the diseases faced by coffee crops is orange rust caused by the fungus *Hemileia vastatrix* Berkeley and Broome, whose main form of multiplication is through urediniospores (Avelino, 2013). Unfortunately, *Coffea arabica* is the species with the highest susceptibility to this fungus (Baker *et al.*, 1992).

According to the phytosanitary epidemiological surveillance program for coffee trees, implemented by SENASICA, in the Huatusco region, a plant severity of $12.9 \pm 7.3\%$ was quantified, which increased to $21.2 \pm 13.6\%$ in 2018. The municipalities with the highest percentage of severity were Teocelo ($28.2 \pm 12.2\%$) and Coatepec ($21.9 \pm 12\%$), while the municipality of Xico registered the lowest value ($16.9 \pm 10\%$; SENASICA, 2016b). Despite this, within the coffee species, it is possible to find rust-tolerant varieties, which can be used for the generation of new resistant lines and with high cup quality.

Among the biological alternatives for the rust problem is the cultivation of varieties of African origin or the cultivation of hybrid plants. One of the problems with the new hybrids (Oro Azteca, Costa Rica, Marseillaise, etc.) is that, although resistant to rust, the quality of the bean and the beverage are considered low, compared to the quality of the coffee that comes from the original varieties (Henderson, 2019).

The Geisha variety, which is a direct descendant of the Arabica species, has been reported as tolerant to rust, and has been evaluated in recent times as a high-quality coffee, with high scores in specialty coffee competitions (Miranda, 2006; World Coffee Research, 2016). For this reason, it is thought that this variety can be studied through an artificial selection process to obtain promising new accessions with desirable characteristics and with great potential for expansion in Mexico.

It is a variety that is not widely cultivated and the little information that exists is scattered and fragmented. Therefore, this work aimed to collect and analyze information on the Geisha coffee variety, on the morphological, productive, environmental, and historical characteristics, susceptibility to diseases and pests, and its current situation in Mexico and in the world.

Review work

We searched for information from published scientific papers, as well as in books and digital theses available online with Google Scholar, Web of Science, and Elsevier search engines, published before January 2021. The terms used in the search were Geisha coffee, coffee plants, Café en Mexico, Geisha variety coffee plants, Geisha coffee cup quality, and café variedad Geisha, in order to compile the information distributed in Mexico and in other countries in which the Geisha variety has been important.

The websites of World Coffee Research, Alliance for Coffee Excellence, Secretaría de Agricultura y Desarrollo Rural (SADER), Specialty Coffee Association (SCA) and perfect daily grind (PDG) were also explored. In addition, informal talks were held through forums on social networks with approximately six coffee producers from the state of Veracruz and four from the state of Chiapas (Productores de café del mundo; World Coffee Producers).

We also had a direct talk with a local producer with great experience and knowledge about coffee (Serafín Morales) from the Huatusco area, from the community of Tlavictapan, Veracruz. This producer worked for more than 30 years at the coffee research center (CRUO of Huatusco), a period that allowed him to accumulate a great knowledge about coffee varieties, including the Geisha variety. In the talks, he was asked his opinion on the growth, pests, and cup quality of the Geisha variety, as well as other varieties.

Background of the Geisha variety

The Geisha variety belongs to the *arabica* species, it is native to Ethiopia from a region near a mountain whose name translates as Gesha or Geisha (World Coffee Research, 2016). Being a variety of African origin, it is considered a wild variety or genetically defined as autochthonous; it is also known as Heirloom (Perfect Daily Grind, 2019).

There is confusion about Geisha plants because multiple genetically distinct plant types have been named Geisha, many of which share similar geographical origins in Ethiopia (World Coffee Research, 2016). Most varieties of *C. arabica* are genetically similar, while morphologically, they present notable differences, and their fruits contrast in quality in pre- and postharvest (Steiger *et al.*, 2002).

Pruvot *et al.* (2020) carried out a genetic analysis for the Geisha variety, with the database of the (World Coffee Research, 2016), it was shown that, of 88 records, 39% exactly matched the Geisha reference (access T.2722 of CATIE), which is related to the variety from Ethiopia. Twenty-four percent of the records were closely related to another individual group also called Geisha and finally, 37% of the samples had genetic backgrounds related to the SL34 variety and others were a Typica-Bourbon blend.

In Brazil, 40 accessions were analyzed and it was found that the Geisha variety and the Cera variety (mutant version of the Bourbon Vermelho variety) showed 80% similarity (Cardamoni *et al.*, 2005); however, in another study of 24 accessions obtained from the museum of collection in Kenya, Geisha was shown to have similarity with the Mocha and Columnaris varieties (Kathurima *et al.*, 2012).

Krishnan (2014) made a genetic comparison between Geisha from Panama and Geisha from Ethiopia and found that they were similar, concluding that Geisha from Panama originated from the same coffee forest as the Ethiopian Geisha. Miranda (2006) conducted an essay on the Geisha variety from Panama, its resistance to rust, how it arrived in Panama, and on its fame as one of the best coffee varieties in 2014.

Characteristics of the Geisha variety

The Geisha variety is tall (more than 3 m), its bud can be bronze or green and is mainly made up of a single stem or main axis; with lateral branches that originate in the axillary buds (ANACAFE, 2016). The secondary branches of the upper part form an angle of 45 degrees in relation to the main axis, and the secondary branches of the middle and lower part form an angle of 60 degrees in relation to this axis; its internodes are open (6 to 8 cm) and its common characteristic is the S shape of the lateral branches of the middle part (ANACAFE, 2016).

The opposite leaves appear on the lateral branches, are oblong-elliptical dark green, and the apical buds can be light green or bronze (Julca *et al.*, 2019). There is no special reported data for the Geisha variety; nevertheless, it shares many of the characteristics of the varieties of the Arabica species.

The flower is composed of inflorescences that form in the bud located in the leaf axils at the nodes of the branches (Arcila, 2007). Its development begins 4 to 5 months before flower opening and they only last three days open and have a strong perfumed aroma of jasmine and citrus (Camayo and Arcila, 1996). The fruit is an oval or ellipsoidal drupe and the fruits are larger than 8-16 mm (León, 1962), it has a late ripening, 34 to 48 weeks after flowering (ANACAFE, 2016).



Reproduction and production cycle

The Geisha variety, being an Arabica variety, shares the same life cycle characteristics as the Typica variety. In commercial plantations, it is productive until 20-25 years of age (Arcila, 2007). The coffee tree has two types of development: i) Vegetative development, which is divided into three stages: germination, seedling, and flowering; and ii) the reproductive phase, which takes place simultaneously with vegetative development during the rest of the plant's life (Arcila, 2007).

The plant begins to produce fruit on one-and-a-half-year-old branches, continues its production for several years, and reaches its maximum yield between 6 and 8 years of age. The plant can continue its activity for many years, but with low yield levels (Arcila, 2007).

Cup quality (organoleptic characteristics)

The cup evaluation of this variety has followed the format established by the Specialty Coffee Association (SCA). In this format, the sensory characteristics of flavor, residue, acidity, body, uniformity, balance, clean cup, sweetness, and aroma are evaluated. Each with a value from 0 to 10, for a total of 100 points maximum. According to the SCA, the cup quality is considered good when the coffee analyzed obtains a score below 80, very good from 80 to 84.99, excellent from 85 to 89.9, and exceptional from 90 to 100 (Specialty Coffee Association, 2003).

The Geisha variety was characterized by having a cup quality that ranges from very good (greater than 80 points) to exceptional. Its flavor ranges from citrus flowers, jasmine, and honey to certain types of fruits (Miranda, 2006; Calle, 2012; World Coffee Research, 2016). In Panama, in 2004, according to a panel of international coffee tasters, the Geisha variety reached 94.6 points out of 100 (Table 1) (Miranda, 2006).

Table 1. Cup quality of the Geisha variety.

Characteristic	Points	Points obtained
Fragrance	10-100	98
Acidity	10-100	88
Body	10-100	70
Flavor	10-100	80
Residue	10-100	80

In another study, in Geisha plantations in Jaramillo and Barú, Panama, the cup quality score was 87.25 and 84.95, respectively (Calle, 2012). Evaluations with lower scores have also been reported; for example, Julca *et al.* (2019) used two Geisha accessions from the coffee germplasm bank in San Ramón, Chanchamayo, Peru, where cup quality scores of 70.5 and 83.75 were obtained, respectively.

In Costa Rica, Geisha made its appearance in 2012 when it scored 87.97, from Finca El Tambor in the Central Valley, the judges described notes with anise, milk chocolate, and blackcurrant. The following year it achieved a score of 90.08 (Finca Palmilera de Tarrazú), with a flavor of plum, raisins, butter, apricot, nectarine, peach, honey, and banana. Among the most outstanding flavors the following have been characterized: floral, jasmine, bergamot, apple, citrus, cocoa, cherry, and chocolate (Alliance for Coffee Excellence, 2022).

Geisha variety yield

The Geisha variety has a low production; however, it is of interest to the coffee grower for its high cup quality and special market. ANACAFE (2016) reported, for this variety, a cherry coffee production of less than 7 500 kg per 0.705 ha. For their part, Alvarado *et al.* (2017) reported 208.84 and 345.34 g of parchment coffee per plant, where the highest yield was 800 to 1 100 g plant⁻¹.

For this reason, it is suggested that, in order to increase production, the practice of early apical pruning should be carried out at the seedling level, planting two seedlings per bag and two plants for each hole and finally, carrying out the bending after planting to select two or more stems that are born from the bent stem (ANACAFE, 2016). Thus, it is indicated that the yield can reach 9 774 g cherry coffee per plant (Zambrano, 1979).

Geisha variety ecology

Environmental conditions and requirements

There is no specific information about the requirements of the Geisha variety. These are assumed to be the same as those required for *C. arabica* var. Typica. In general, coffee is best adapted to cold climates, where the average annual temperature favorable for the coffee tree is between 17 and 25.3 °C and the optimal altitude is greater than 1 200 m, although it can tolerate higher altitudes than conventional ones (World Coffee Research, 2016). In rainfall, for a good development of the coffee tree, 760 to 1 780 mm and a humidity of 70 to 95% are required.

In terms of nutrients, nitrogen (N), potassium (K) and in smaller quantities, phosphorus (P) are necessary (Sotomayor, 1993). It does well in soils with a pH of 5 to 6 (Arcila, 2007). Shade is also a favorable condition for this variety; for example, semi-shaded coffee has multiple advantages, one of them being that the plants remain with more foliage throughout the year and in a better state of health (Turbay *et al.*, 2013).

In winter, trees help regulate the erosive effect of rainfall, and in summer, they keep soil moisture more stable (Turbay *et al.*, 2013). Silva (2019) described the morphological behavior related to height, number of leaves, and root development for 19 months (7 months in the seedling bed and 12 months in the field).

In the seedling bed, it was observed that growth was continuous and proportional, while in the field, the plants grew rapidly, although root growth was lower and occurred more slowly. This same author estimated costs and budgets for the establishment of plantations of this variety in order to carry out protocols to produce fine coffees, such as Geisha.

Susceptibility to disease

There are several diseases and pests that attack coffee; for the Geisha variety, the most common are: the coffee berry borer (*Hypothenemus hampei*), which is an insect of the order Coleoptera that reduces the harvest by up to 50%, by reducing the physical qualities of the bean (Sánchez *et al.*, 2018). This pest affects 3.53 to 4.47% of crops, where the Catimor variety is one of the most susceptible, with a percentage greater than 19% (Alvarado *et al.*, 2017).

The leaf miner (*Leucoptera coffeella*), which is a monophagous moth (it is only capable of attacking coffee plants), causes damage by the larvae feeding on the leaves. At first, the leaves are light green and later, they turn light brown or blackish. In Mexico, this pest is under monitoring within the phytosanitary epidemiological surveillance program in coffee-producing states (SENASICA, 2016a).

The root mealybug (*Planococcus lilacinus*), this pest produces discoloration of the leaves and necrosis at the edges, which gives the plant a withered appearance that causes partial or total fall of the foliage (SENASICA, 2014). In Mexico, there are no reports of this pest; nonetheless, it is present in countries in the Americas, in the Dominican Republic, El Salvador, Guyana, and Haiti (SENASICA, 2014).

Finally, coffee rust (*Hemileia vastatrix*), a fungus that causes severe defoliation, can reduce coffee yields by 30% to 60% (SENASICA, 2016b). This is one of the main diseases faced by coffee crops (Avelino, 2013). In Mexico, rust has also been reported in the main coffee-producing states (SENASICA, 2016b).

Rust tolerance

According to genetic studies, the presence of four dominant genes for rust resistance is reported for *C. arabica*: SH1, SH2, SH4, and SH5 (Sera *et al.*, 2007; Gichimu, 2012; Teixeira *et al.*, 2015). The resistance genes SH1 and SH4 are located in the so-called 'forest' areas of Ethiopia and are normally associated with plants with low production (Rodríguez, 1990).

One of the characteristics of the Geisha variety is that it possesses at least two of the resistance genes, SH1 and SH5, which confer resistance or tolerance to several races of rust (Pérez and Gutiérrez, 1978). In a study carried out by Estrada (2014) on the severity of *Hemileia vastatrix* in the varieties of Catuai, Geisha, Costa Rica 95, Catimor, Colombia and Limaní, in nursery conditions, Geisha had the highest vegetative development with the best characteristics in height, stem diameter, and number of leaves and showed resistance to rust.

Gichimu (2012) identified possible sources of rust resistance genes; the infection was evaluated from 45 accessions of *C. arabica* under field conditions. Significant variation in rust tolerance was observed between genotypes and tolerant genotypes were identified in the varieties evaluated, Geisha showed tolerance. Most of the accessions that demonstrated high phenotypic resistance have not been used as sources of rust resistance in coffee improvement programs and the author concluded that such genotypes could represent a very valuable resource for their reproduction.

Route from Ethiopia to Mexico

Worldwide distribution

Geisha is a variety that originated on the African continent in the forests of Ethiopia, later it was introduced to Kenya and later, to Tanzania, although there is no exact reference to the year (León, 1962). Subsequently, in 1953, it arrived in Costa Rica at the garden of the Inter-American Institute of Agricultural Sciences (IICA) for the purpose of testing it for resistance to *H. vastatrix* Berk et Br (ANACAFE, 2016).

This variety was shown to be resistant to certain genes of rust race II; nevertheless, it was also determined that it had a poor productive performance compared to small cultivars, such as Caturra and Catuai. Therefore, Geisha stopped being planted and few lots remained (ANACAFE, 2016). It is currently commonly produced in Panama, where it has gained the prestige of quality coffee.

Germplasm banks have been reported in Ecuador (Amores *et al.*, 2004), Peru (Julca *et al.*, 2019), Mexico (Escamilla, 2016) and Costa Rica (Fórum del café, 2020). The first record of this variety was made by León (1962), who made a manual of coffee cultivar species with reference to the collections represented at the Inter-American Institute of Agricultural Sciences in Turrialba, Costa Rica.

In this manual, the Geisha variety is described with the characteristics that are currently known. Gutierrez *et al.* (1969) conducted yield tests on coffee plants introduced to Costa Rica in 1962-1967; Pérez and Gutiérrez (1978) also carried out yield studies of coffee varieties at different planting densities; on the other hand, Bettencourt (1982) analyzed varieties of Arabica coffee resistant to rust with the aim of using them in the future. In this latest work, Geisha is described as having the rust resistance genes SH1 and SH5.

Geisha spread in Mexico and its reputation as quality coffee

The Geisha variety was introduced to Mexico in 1980 through the Mexican Coffee Institute (INMECAFE), for its acronym in Spanish. This organization distributed the plants in the states of Veracruz, Oaxaca, and Chiapas (Escamilla, 2016). With the disappearance of INMECAFE, today this variety is registered by the Chapingo Autonomous University (CRUO-CENACAFÉ), with the registration number caf-019-170616 (Escamilla, 2016; SNICS, 2019).

Currently, in Mexico, the number of farms engaged in the production of this variety is small; however, suppliers of genetic material have been reported in municipalities in the states of Oaxaca, Guerrero,

Veracruz, and Hidalgo (SADER, 2019). In 1999, cup of excellence (COE) and the Specialty Coffee Association of America developed an auction platform for specialty coffees (Alliance for Coffee Excellence), which has allowed producers to obtain a higher price for their products.

This competition is the most prestigious for high-quality coffees (Alliance for Coffee Excellence, 2019). For the state of Veracruz, in 2021, Geisha had a score above 86. In the Coatepec area, Finca Cafetal Equimite obtained a score of 88.1; in Zongolica, Finca El Estribo 88.2 points; in Ixhuacán, Finca Palma reached 87.8 points; in Totutla, Finca Corahe, La Orduña, Finca Trebolillos and Tlaltetela, Finca las Trincheras obtained 87 points (Alliance for Coffee Excellence, 2021).

In the 2022 contest, Finca el Izote, located in Naolinco, obtained the highest score with 91.4 and Finca Cafetal Equimite, Finca Palma and Finca Trebolillos also participated again, which had higher scores than the previous year: 89.53, 89.43 and 89, respectively (Alliance for Coffee Excellence, 2022). Similarly, the state of Chiapas has obtained high scores with the Geisha variety; for example, Finca Santa Cruz in La Concordia obtained scores of 91.58 and 93 in the years 2001 and 2022, while Finca San Luis and Finca Geisha of the locality of Ocozocoautla obtained 90.25 and 91.13 points, respectively (Alliance for Coffee Excellence, 2022).

Current commercial importance

After the Geisha variety from Finca Esmeralda in Panama scored high in cup quality in 2004 as the best in Panama, the coffee was auctioned for a price of 21 dollars per 0.45 kg (Miranda, 2006). In the auctions of the Alliance for Coffee excellence, this variety grown in Mexico has reached a value of 90 to 92 dollars per 0.45 kg (Alliance for Coffee Excellence, 2022) and currently, Geisha has a value of 61 to 10.1 dollars per pound (Alliance for Coffee Excellence, 2023). In the interior of the country, this coffee has a value of 26.99 dollars per kilogram, certified, with a sensory quality of 8.5; that is, excellent coffee (producers' personal communication).

Geisha variety and other Arabica varieties and hybrids

Authors such as Jáuregui *et al.* (2017) mention that some of the varieties grown in the state of Veracruz are Typica, Garnica, and Costa Rica, with approximately 20 to 33%, while the Geisha, Caturra, and Oro Azteca varieties are cultivated in a percentage of less than 20%. Both Typica and Geisha are of Ethiopian origin, so they have high cup quality; nevertheless, Typica is considered susceptible to rust and Geisha as tolerant (Table 2). The Costa Rica, Colombia, and Oro Azteca varieties are hybrids, resistant to rust, but are considered to have a lower cup quality (López *et al.*, 2016; World Coffee Research, 2016; Jáuregui *et al.*, 2017) (Table 2).

Table 2. Resistance and cup quality of coffee varieties (Jáuregui *et al.*, 2017; Alliance For Coffee Excellence, 2019; World Coffee Research, 2016).

Variety	Origin	Resistance to rust	Cup quality	Process
Geisha	Ethiopian	Tolerant	93.7	Natural
Bourbon	Ethiopian	Susceptible	90.3	Honey
Typica	Ethiopian	Susceptible	89.4	Wet
Garnica	Cross	Susceptible	88.2	Natural
Costa Rica	Catimor hybrid	Resistant	87.5	Wet
Caturra	Bourbon mutant	Susceptible	87.3	Wet
Oro Azteca	Catimor hybrid	Resistant	86.8	Wet

The Geisha variety is an Arabica variety native to the forests of Ethiopia, so it shares the characteristics of high cup quality and rust tolerance with the Typica and Bourbon varieties (Pérez and Gutiérrez, 1978). Due to its low production and high size, producers lost interest in this crop (Miranda, 2006) and although the variety continued to be cultivated, it was in smaller quantities, so there is little information about it.

After 2004, when the Geisha variety won the contest of 'Best of Panama' as the coffee with the best cup quality, it regained its fame internationally, and the interest of tasters, producers, researchers, and the general public was reactivated. In Mexico, this variety is little cultivated, the existing plantations are young (no older than 10 years); this is because only in 2006 some producers, mainly in the area of Chiapas, acquired the seed of Panama origin due to the increase in its popularity.

In Veracruz, there are farms where this variety is grown and they have participated in international auctions, obtaining a cup quality greater than 86 (Alliance for Coffee Excellence, 2019). There are also farms registered with the Secretariat of Agriculture and Rural Development (SADER, 2019) and unregistered farms, such as in the area of Huatusco, Zongolica, and Totutla, in the state of Veracruz; Zongozotla, Puebla and the Northern Sierra of the state of Oaxaca.

From comments by producers, it is known that there are still plantations that are descendants of those introduced by INMECAFE (1980), some still preserved and others abandoned, while the plantations of others are of seeds obtained from Geisha of Panama (producers' comment).

Information about this variety is still unknown; some authors mention that being an Arabica variety, it shares the same characteristics (Silva, 2019) as Typica, including nutritional requirements, phenological cycle, climate and altitude, cup quality, the same characteristics that producers look for in their coffee plantations, in addition to tolerance to rust. This is unlike hybrids, which, although resistant to rust, their quality in the cup has been questioned.

Conclusions

In Mexico, there is local coffee germplasm of the Geisha variety, both on registered farms certified for international sales and on farms that are engaged in cultivation for local consumption. Some producers report a high cup quality of 85 to 93 points according to the specialty coffee association (SCA), which is why it is classified as an excellent coffee.

With the germplasm that exists in Mexico and adapted to the region, genetic improvement programs and selection of promising new lines can be proposed for future expansion programs among producers within the different regions of the country. Because there is little information about the variety, it is suggested to carry out research to recover and reproduce the existing germplasm of the plants descended from those introduced at the end of the 80s and to carry out future cultivation manuals of this variety, adapted to the environmental conditions of Mexico. This review also highlights the opportunity to make international agreements with the countries of Panama or Costa Rica, which have the certified variety, and share promising plant lines.

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