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A systematic literature review on environmental, agronomic, and socioeconomic factors for the integration of small-scale coffee producers into specialized markets in Oaxaca, Mexico

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The coffee sector's challenges, such as low and volatile prices, prompt adopting strategies focused on product differentiation, including high-quality specialty coffee. Nevertheless, documented evidence shows that small producers in Oaxaca, Mexico, are not equally benefiting from this market opportunity compared to other states in Mexico, such as Veracruz or Chiapas. This review article identifies and analyzes the factors in integrating small Oaxacan producers into the specialty market. A total of 138 scientific contributions were analyzed, emphasizing three thematic axes: (1) Trends and behavior of the coffee market. (2) Factors to enable the production of high-quality coffee, and (3) Current situation and challenges of small coffee producers in the specialized market. We found that coffee quality depends on the environment (mainly altitude, temperature, and geographical conditions) and agronomic, genetic, and socio-economic factors. Moreover, agronomic and genetic factors should focus on choosing coffee varieties suited to the environmental conditions of the farm and adopting innovations in production, harvest, and post-harvest processes. The most significant socio-economic factors that hinder small coffee producers' participation in the specialized market include but are not limited to, lack of information, social connection, and financial resources. However, in the literature analyzed here, it was also possible to identify specific farmworker experiences that operate with a community approach and have inserted their small producers into high-quality market transactions. For this reason, this article suggests that the standardization model of quality from the collective approach within the community-based enterprise is a sustainable and inclusive alternative to achieve the goal: the insertion of small Oaxacan coffee producers into the more significant specialty market.

KEYWORDS

coffee, factors, high quality, small producers, market insertion

1 Introduction

Coffee (*Coffea arabica* L., Gentianales: Rubiaceae) is a crop of significant agricultural and commercial importance. Coffee is cultivated in 80 countries across Latin America, Africa, and Asia, involving over 100 million people in its production and processing (Panhuysen and Pierrot, 2014; Monsalve, 2022). Mexico ranks fifth in Arabica coffee production, surpassing Brazil, Colombia, Honduras, and Ethiopia (Gumecindo et al., 2021). In Mexico, coffee is the seventh-largest agricultural crop and the twelfth most valuable farm product (Servín et al., 2021). In Mexico, Veracruz and Chiapas state have first and second place in areas planted with coffee in the country, and Oaxaca ranks third; however, by quantity produced in tons of coffee, Oaxaca occupies fourth place (Fideicomisos Instituidos en Relación con la Agricultura – FIRA, 2016; Ramírez et al., 2023; Servicio de Información Agroalimentaria y Pesquera SIAP, 2023a). In Oaxaca, the latest official complete register recorded 102,159 coffee producers (CECAFE, 2011), but in 2014, the National Coffee Register compiled by SIAP showed 104,755 coffee producers (PNC-SIAP, 2014). In 2020 the PNC-SIAP still considered 104,000 producers. Until 2024, there has not been a coffee census with informative data as complete and specific as the one CECAFE carried out in 2011. These producers occupy an area of 132,923.1 ha (García et al., 2021; Servicio de Información Agroalimentaria y Pesquera SIAP, 2023a), in 151 municipalities in the state (Servicio de Información Agroalimentaria y Pesquera SIAP, 2022b). Out of all the producers, 64% operate as smallholders in an area of less than 1 ha (Becerra, 2013; Fideicomisos Instituidos en Relación con la Agricultura – FIRA, 2014; Servicio de Información Agroalimentaria y Pesquera SIAP, 2022b). Consequently, "smallholder" is one of the primary focal points of this review article.

Coffee producers face a constant market problem: price fluctuations and volatility (Muñoz et al., 2015, 2019; Canet et al., 2016; Servicio de Información Agroalimentaria y Pesquera SIAP, 2023b). This is because coffee is a global commodity and, as such, is listed on stock exchanges, specifically Arabica coffee on the New York Stock Exchange (Akaki and Echánove, 2006; Figueroa et al., 2019). Coffee is traded in the commodities and futures market, characterized by constantly oscillating prices (Akaki and Echánove, 2006; Barrios et al., 2022). Coffee is not exempt from these dynamics (Gilbert et al., 2005; Akaki and Echánove, 2006; Muñoz et al., 2015, 2019). To mitigate this risk, strategies focused on product differentiation have been developed by innovative producers (Deugd, 2003; Oficina de Estudios Económicos y Estadísticos, 2013; Muñoz et al., 2015). One of these is the production of high-quality specialty coffees, driven by the emergence of new markets with consumption trends focused on coffee quality (Oficina de Estudios Económicos y Estadísticos, 2013; Dilas et al., 2020). These new consumption patterns are associated with the significant growth of high-end coffee shops and high-quality luxury coffee products (Akaki and Echánove, 2006; Muñoz et al., 2015; Bianco, 2020). This trend has created an opportunity for specific producers to introduce their products with prices tied to quality, thereby establishing the specialty coffee market niche (Deugd, 2003; Muñoz et al., 2015; de Barbosa et al., 2020).

High-quality specialty coffees are characterized by their unique sensory qualities, highlighted in elevated scores in cupping tastings (Aragón, 2016). The most widely accepted scale for this evaluation is that established by the Specialty Coffee Association of America (SCAA), which defines specialty coffees as those that score 80 points or more (SCAN Guatemala – Plataforma Nacional de Café Sostenible, 2015; Aragón, 2016; Pragathi and Lija, 2022; Amecafé-ACE, 2023a). This same scale is used to evaluate extraordinary coffees that compete for their quality in cup of excellence competitions organized by the Asociación Mexicana de la Cadena Productiva del Café A.C (Amecafé) in collaboration with the Alliance for Coffee Excellence (ACE). This level of distinction requires a rigorous production process. Cup purity, a unique flavor profile, and strict origin control or traceability characterize high-quality coffees. They must have no primary defects and a maximum of five secondary defects while still maintaining the quality of the green bean (Barbosa et al., 2012, 2019; Amecafé-ACE, 2023a). Another fundamental characteristic of high-quality coffee is that it is independent of coffee prices established on the New York Stock Exchange. Instead, the price is established taking only as a mere reference the prices of "other mild coffees" listed on this exchange, to which a premium is added based on the quality (cupping score), origin, exclusivity of the coffee, and the agreement reached between the producer and the customer (Aragón, 2016; Vegro and De Almeida, 2020; Bozzola et al. 2022).

This review article chooses the state of Oaxaca as a focal point for analyzing the specialty market in Mexico because Oaxaca has distinguished itself in the coffee industry by participating in competitions like the Cup of Excellence, where the finest coffees from Mexico and worldwide vie for top honors. Oaxacan Coffee has consistently ranked in the top 10 and obtained first place nationally in the 2023 contest with a score of 91 points in the cup, demonstrating its exceptional quality (Amecafé-ACE, 2023b). Despite the 104,000 coffee producers in Oaxaca, only 0.1% have been identified as exceptional coffee producers (CRUS UACh Presentation, 2014; Aragón, 2016; García et al., 2021). However, according to Aragón (2016), 43.34% of all producers in this state meet the criteria of "potential producers," mainly due to climatic, geographical, and altitude factors (Aragón, 2016; Jaramillo et al., 2022).

Therefore, the primary goal of this review is to identify and analyze in a scientific bibliography the environmental and agronomic factors essential in producing high-quality coffee, as well as the socio-economic factors involved in the participation of small producers in the specialty coffee market. This is to propose a viable and sustainable alternative so that small coffee producers in Oaxaca can enter the specialty coffee market and take advantage of its benefits. The aim is to gather scientific information from the past two decades that addresses these aspects while also identifying unexplored areas of knowledge and proposing potential directions for future studies.

2 Materials and methods

2.1 Search strategy

To conduct a systematic literature review, we defined three thematic axes.

1 Coffee Market Trends and Behavior.
2 Factors enabling the production of high-quality coffee.
3 Current Situation and Challenges of Small Coffee Producers in the Specialized Market.

We collected the information by conducting a systematic literature search of the databases of the main scientific journal indexes: Elsevier, Scientific Electronic Library Online (SciELO), Red de Revistas Científicas de América Latina y el Caribe, España y Portugal (Redalyc), and Dialnet. Scopus, ScienceDirect, and Google Scholar were the primary search engines utilized. The general queries used were: [(coffee) AND (specialty coffee)], [(coffee) AND (quality coffee)], [(genotype) AND (specialty coffee)], [(factors) AND (quality coffee)], [(shade) AND (specialty coffee)], [(altitude) AND (specialty coffee)], [(small coffee producers) AND (high quality)], [(small coffee producers) AND (market opportunities)], [(small coffee producers) AND (high quality) AND (Oaxaca)], [(Oaxaca) AND (specialty coffee)].

As the majority of government research is written in Spanish, we use the following secondary search routes: [(café de especialidad) AND (nichos de mercados)] y [(café) AND (inserción a mercados)], [nicho de mercado de café especial], [café de especialidad], [calidad en taza], [(variedades de café) AND (Alta calidad en taza)], [(genotipo de café) AND (alta calidad en taza)], [(Proceso productivo) AND (alta calidad)], [(pequeños productores) AND (café) AND (Oaxaca)], [(pequeños productores) AND (café de especialidad)] [(Oaxaca) AND (café de especialidad)]. This search route includes the niche of the specialty coffee market, specialty coffee, cup quality, coffee varieties with high cup quality, coffee genotype with high cup quality, production process for high quality, and small producers in the coffee, specialty coffee in Oaxaca and specialty coffee sectors.

2.2 Inclusion criteria for sample determination

A total of 214 documents relevant to the analysis axes and keywords provided were identified and formed the population for this review. Two sampling techniques were used to create the analysis sample. The first method is finite population sampling, which involves selecting a subset of elements from a statistical population (U) to infer characteristics of the entire population and draw representative conclusions. The finite population sampling formula (López and Fachelli, 2015) was used with a confidence level of 95% and a margin of error of 0.5, resulting in a sample size of 138 documents. A second technique was applied to analyze and identify the 138 documents in the sample qualitatively, as well as to further explore the information. The documents selected had to meet the following requirements:

1 Documents with scientific rigor (scientific articles, technical documents, annexes, reports, books, theses, and official dissemination documents) on coffee at international, national, and local levels, containing information on the three axes mentioned above in the analysis.
2 Documents containing detailed information about high-quality specialty coffees, including production, processing, marketing, organizational, social, and cultural aspects.
3 The scientific quality was assessed based on the following criteria: 70% from a scientific bibliography available in articles, and 15% from appendices, conferences, and official websites. 15% of the literature consists of gray literature, including books, theses, technical, and official documents.
4 Manuscripts published within the specified time interval; the search period was extended to the last 20 years. The age of the publication date has only been ignored in the most important old bibliography, and we allow up to 15% of this, as a result 21 of the 138 documents in the sample are equal to or older than 2004. The criteria for considering old references were mainly: bibliography cited for their theoretical importance in the coffee sector at the national and local level; references from "classical" authors that describe the period of transition to the free market, the beginning of product differentiation and the evolution of the coffee market.

2.3 Analysis of the information

Out of the 214 documents that comprised the population in this review, a sample of 138 documents was determined using the sampling technique and inclusion criteria described in the previous section. Of these, 97 were scientific articles from indexed journals, representing 70% of the sample. Another 20 documents were identified, including appendices, conference proceedings, and official data from national and state government websites, representing 15% of the total sample. Finally, 21 documents were identified as "gray literature," comprising eight books, eight technical and official dissemination documents, and five theses, making up the remaining 15% of the sample; this literature was allowed in this review due to the importance of its content, especially the information verified in Theses and registered Books.

The analysis was carried out using the activities described in the flowchart shown in Figure 1. Two dominant lines of scientific research were identified in the total sample of documents: (1) socio-economic research and (2) agro-environmental research. Therefore, the documents were separated based on these lines of research, then organized and classified into the main topics and sub-topics. As a result, it was possible to identify six factors that small producers should consider when entering the specialty market.

3 Results and discussion

3.1 The situation of coffee production in Oaxaca

In 2023, approximately 75.0% of global coffee production was concentrated in five countries: Brazil (37.0%), Vietnam (18.0%), Colombia (8.0%), Indonesia (7.0%), and Ethiopia (5.0%). Mexico ranks tenth, accounting for 2.0% of world production (United States

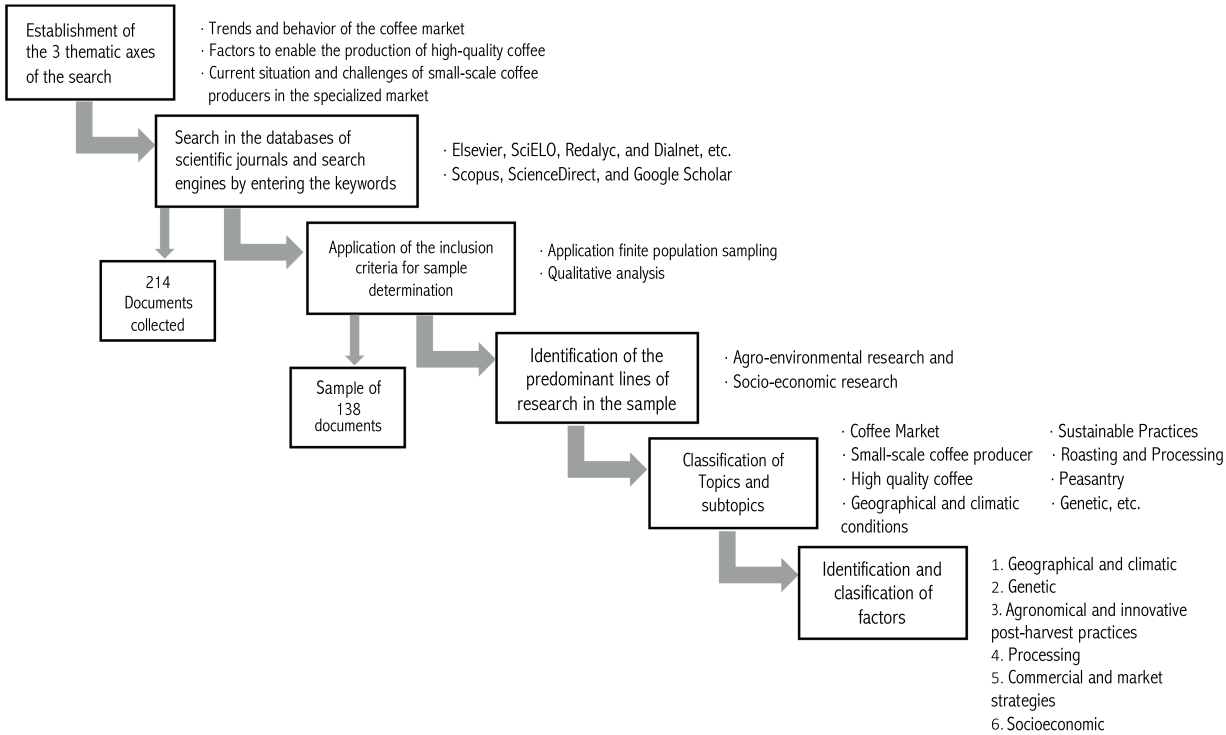

FIGURE 1
Information analysis flow chart.

Department of Agriculture – USDA, FAS, 2023). Nationally, the coffee industry in Mexico directly and indirectly employs nearly 3 million people and is supported by just over 500,000 producers (Fideicomisos Instituidos en Relación con la Agricultura – FIRA, 2014). In the 2022/23 coffee cycle, 702,686.02 ha were allocated to coffee cultivation in the country. In this area, 648,487.1 ha were harvested, with the majority of this activity concentrated in five primary states: Chiapas (36.2%), Veracruz (21.0%), Puebla (10.7%), Oaxaca (17.3%), and Guerrero (6.0%) (Fideicomisos Instituidos en Relación con la Agricultura – FIRA, 2016; United States Department of Agriculture – USDA, FAS, 2023; Servicio de Información Agroalimentaria y Pesquera SIAP, 2023b).

The state of Oaxaca has an orography shaped by a network of mountain ranges that stem from the Mexican Central Plateau and the North American Rockies, resulting in diverse climatic conditions ideal for coffee cultivation. Coffee cultivation is widespread throughout much of the state, including seven out of its eight regions. The Costa, Cañada, and Sierra Norte regions have the largest area under coffee cultivation and the highest production (CECAFE, 2011; Servicio de Información Agroalimentaria y Pesquera SIAP, 2022a; Table 1). Regarding the varieties commonly grown in the state, *C. arabica* is the most predominant, especially the Typica, Bourbon, and Caturra varieties (Aragón, 2016; Jaramillo et al., 2022).

In Oaxaca, coffee producers are classified based on the planted area, showing two distinct contrasts as highlighted by Becerra (2013): large-scale farmers and small-scale producers. However, most coffee production in the state comes from small producers, primarily members of indigenous communities (Becerra, 2013; Juárez and López, 2021). Large farmers make up 17% of the plantations and only 0.4% of the total producers (Piñón and Hernández, 1998; Morales and Anguiano, 2022). For example, in the official register of Oaxaca, there are plots of land identified with extreme sizes, ranging from 300.81 ha in San Gabriel Mixtepec to as small as 0.12 ha in Zochitonalco, demonstrating a significant diversity in the state's production scale (CECAFE, 2011).

In this analysis, a "small producer" is defined as owning 5 hectares or fewer of coffee land. We analyzed the CECAFE national register of coffee producers (2011) and the SIAP census (2014) and found that 99,953 producers own 5 ha or less. This means that 98% of coffee growers in Oaxaca are smallholders. The successful integration of these small producers into the specialized market niche requires knowledge of market behavior and a thorough review of the factors involved in producing quality coffee. It also involves identifying viable and inclusive alternatives to achieve this goal.

3.2 Niche markets for high-quality specialty coffees

Specialty coffees, also known as gourmet or premium coffees, have distinctive characteristics, particularly in terms of flavor, production processes, conditions of origin, and marketing, which are tailored to the requirements of specific roasters and consumers (Canet et al., 2016). In addition, the supply of specialty coffees in the global market is significantly scarce. Together, these factors allow specialty coffees to be sold at significantly higher prices, offering producers a way out of the current coffee crisis (Muñoz et al., 2015; Aragón, 2016; Canet et al., 2016). According to Muñoz et al. (2015), the prices obtained for these coffees can be up to 10 times higher than those for conventional coffee. Meanwhile, Castro (2018) argues that producers can potentially quadruple their income by entering this niche market.

TABLE 1 Presents the coffee production situation in Oaxaca by region at the end of the agricultural year 2022/23 (Servicio de Información Agroalimentaria y Pesquera SIAP, 2022a).

No	Region	No. of municipalities	Sup. (ha) sown	Sup. (ha) harvested	Sup. (ha) damaged	Production (t)	Yield (t/ha)	Production value (mmp)
1	Cañada	28	20,380.55	20,239.96	0.00	15,234.53	21.44	79,376,944.42
2	Costa	34	49,339.00	33,750.75	0.00	15,416.59	15.44	94,583,041.44
3	Mixteca	10	8,675.70	8,569.60	0.00	7,335.50	8.54	46,505,141.91
4	Istmo	14	14,112.20	13,391.20	0.00	8,526.60	9.61	46,259,419.81
5	Sierra Norte	32	15,026.25	14,621.25	0.00	14,649.65	32.79	69,137,606.34
6	Papaloapan	19	19,720.00	17,569.00	0.00	18,850.25	18.43	90,022,953.84
7	Sierra Sur	13	7,128.90	7,082.20	0.00	9,063.94	17.66	47,259,258.61
	Total	150	134,382.60	115,223.96	0.00	89,077.06	123.91	473,144,366.37

mmp, millions of Mexican pesos.

Furthermore, the coffee industry is undergoing a significant transformation from commercial to specialty coffee (Castro, 2018), because the demand for high-quality specialty coffee has increased significantly due to high consumption in traditional markets such as the European Union, the United States, and Japan, as well as the emergence of new markets such as Korea and China, which are showing a growing preference for high-quality coffee (Oficina de Estudios Económicos y Estadísticos, 2013).

In the industry, the definition of specialty coffee encompasses two aspects. On the one hand, the intrinsic aspects of the product, such as flavor, are influenced by moisture content, bean size, presence or absence of defects, origin, biochemical compounds, and sensory quality (Leroy et al., 2006; Amecafé-ACE, 2019). On the other hand, extrinsic aspects related to production systems supported by certifications that identify them as sustainable and certified coffees are considered (Renard, 2010; Sepúlveda et al., 2016). Another approach is derived from the consumer's perspective, focusing on their preferences for the quality of the product in the cup (Oficina de Estudios Económicos y Estadísticos, 2013). In general, consumers identify specialty coffees based on unique characteristics that distinguish them from conventional coffees, especially those whose quality is linked to their origin (Sepúlveda et al., 2016). Consumer demand is driven by product attributes that align with their preferences, including price, taste, health benefits, geographic origin, and environmental and socio-cultural aspects (Leroy et al., 2006).

According to the Specialty Coffee Association (SCA). In 2019, the criteria for attaining a high-quality specialty grade based on the physical attributes of the coffee bean are as follows: (a) no category one defects and a maximum of five category two defects in a 350-gram sample of green coffee (Table 2), (b) a maximum deviation of 20% above and below sieve sizes 16–18, (c) absence of hollow or empty beans post-roasting, (d) moisture content ranging between 10 and 12%, and (e) water activity levels not exceeding 0.65 points (Specialty Coffee Association – SCA, 2019). In terms of sensory quality, the coffee must have a cup profile equal to or greater than 80 points on the Specialty Coffee Association of America-SCAA (2011) scale. It must be free of primary defects or impurities and must be distinctive in one or more of the following characteristics: flavor, acidity, body, and aroma. The classification into special quality categories according to the score obtained on the Specialty Coffee Association of America-SCAA (2011) scale is as follows: (a) less than 80: low exceptional quality, (b) 80–84.99: special, (c) 85–89.99: particular origin or exemplary, and (d) 90–100: rare specialty or unique coffees. Achieving this differentiation by producing high-quality specialty coffees with the above cup profiles requires a rigorous process at each stage of the production chain. Several factors can influence the integration of small coffee producers in Oaxaca into the specialty market.

TABLE 2 Table of equivalent defects (Specialty Coffee Association – SCA, 2019).

Defects of category 1	Equivalents of complete defects	Defects of category 2	Complete defect equivalents
Black grain	1	Partial black grain	3
Sour grain	1	Partial sour grain	3
Dried cherry	1	Parchment	5
Fungal damage	1	Float	5
Foreign matter	1	Immature	5
Severely damaged by insects	5	Stormed	5
		Shell	5
		Split / Bitten / Cut	5
		Husk	5
		Slightly damaged by insects	10

3.3 Agro-environmental factors segment

3.3.1 Geographical and climatic factors

The environmental and geographical conditions under which coffee is grown are critical to the quality of the product. These conditions directly influence the major chemical components of the coffee bean, including lipids, chlorogenic acids, sugars, and caffeine. Therefore, climatic and geographic factors should be a priority for coffee farmers seeking access to the high-quality specialty market (Muschler, 2001; Decazy et al., 2003; Da Silva et al., 2005; Leroy et al., 2006; Joët et al., 2010; Oberthür et al., 2011; Bertrand et al., 2012; Neves et al., 2012; Aranda et al., 2014; Joët et al., 2014; Mendonça et al., 2016; Pham et al., 2019). Geographical location determines the volatile compounds present in coffee, which directly influence its aroma. More than 700 compounds have been identified and they vary between regions due to differences in the biochemical and sensory properties of coffee (Costa and Mosca, 1999; Oberthür et al., 2011; Volsi et al., 2019).

Altitude is one of the most important factors, especially for Arabica coffee, as it profoundly affects its quality. Daily variations in temperature, the amount and distribution of rainfall, and the physical and chemical state of the soil have a direct impact on coffee quality (Muschler, 2001; Decazy et al., 2003; Bote and Vos, 2017; Song et al., 2021). In particular, altitude is considered critical because it is associated with increased shade and lower temperatures, which delay fruit ripening and improve coffee quality. This delay in ripening leads to improved granulometry and an increase in acidity and caffeine, which are critical parameters for aroma formation (Guyot et al., 1996; Avelino et al., 2005, 2007; Joët et al., 2010; Sridevi and Giridhar, 2013; De Souza et al., 2016; Kath et al., 2021).

According to Lambot et al. (2017) and Davis et al. (2006), the optimal qualities of Arabica coffee are found at altitudes between 1,200 and 1,950 masl (Kath et al., 2021). However, Buenaventura and Castaño (2002) narrowed this range, indicating that the altitude range with the highest quality values is between 1,450 and 1,650 masl, considered ideal for cultivating Arabica coffee. In the specific context of coffee production in Oaxaca, Ovando et al. (2017) proposed a classification based on altitude: washed premium coffee is harvested between 600 and 900 masl, high-altitude coffee between 900 and 1,200 masl, and strictly high-altitude coffee between 1,200 and 1,600 masl. The latter is considered a niche for high-quality coffee (Chávez and Ordoñez, 2021). Aragón (2016) agrees that coffee plantations at 1,200 masl and above achieve a quality score of 80 points or more on the cupping scale. Therefore, this study suggests that smallholder producers at lower altitudes should prioritize productivity strategies to increase yield, while producers at 1,200 masl and higher should focus on strategies to improve quality.

Aragón (2016) analyzed potential specialty coffee producers in Oaxaca by combining the CECAFE producer register (2011) with the altitude database of Oaxaca localities. The results showed that out of the 102,159 registered producers, 44,276 met the altitude criterion for their land, indicating that 43.34% of them could produce high-quality coffee based on this variable. For this study, the group of 44,276 producers was assessed to identify those with 5 ha or less of land under cultivation, which aligns with the definition of "small producer" used in this study. The study identified 43,095 potential small-scale producers, accounting for 42% of the total producers in the registry (Chávez and Ordoñez, 2021).

Shade is crucial for coffee quality, particularly in jungle environments at optimal altitudes (>1,100 masl) (Vaast et al., 2005). Vaast et al. (2006) found that shade improves coffee quality by extending the ripening period of the berries. This leads to improved seed formation, larger seed size, and improved biochemical composition, including increased phenolic content and antioxidant activity (Vaast et al., 2005; Milla et al., 2019). This progress is associated with increased perisperm tissue development under shade (Avelino et al., 2007; Geromel et al., 2008; Somporn et al., 2012; de Carvalho et al., 2021). Coffee grown in full sun at low elevations tends to have a more bitter and astringent taste than coffee grown in shade at higher elevations. In addition, shade-grown coffee has higher acidity and drinkability than coffee grown in full sun (Bertrand et al., 2012).

The state of Oaxaca is geographically ideal for shade-grown coffee due to its orography, shaped by mountain ranges of the Mexican Central Plateau and the North American Rockies (López, 2009). Bartra et al. (2011), Aragón (2016), and Ovando et al. (2017) confirm that in Oaxaca, 40% of coffee production takes place in areas with high and medium forests (humid tropical zone), 23% in pine and oak forests, 21% in low deciduous forests, and 15% in mountain cloud forests. Furthermore, mention that coffee cultivation in Oaxaca is mostly done under shade, and it is common for producers to intercrop fruit and timber crops with coffee plots. Likewise, Belay et al. (2016) mention that temperature is a critical factor affecting the quality of coffee beans. Joët et al. (2010) and Joët et al. (2014) state that the mean air temperature has a predictable effect on the metabolism of fatty acids, sugars, and chlorogenic acid, leading to changes in the chemical composition of mature seeds through subtle transcriptional regulation during their development (Getachew et al., 2022).

A study by Bertrand et al. (2012) found that high temperatures alter the chemical composition of the coffee bean during its development, which impacts the presence of volatile organic compounds. This change affects the quality of the beverage, resulting in earthy and green flavors that become more pronounced as the temperature increases (Pruvot et al., 2020). Rising temperatures are not conducive to plant growth. It disrupts phenological stages, particularly pollination and flowering, and shortens the ripening time of the cherry. Ripening time directly affects the quality of the beans and the final drink. The optimal temperature range for growing Arabica coffee is between 15°C and 24°C. This species flowers at higher altitudes (Panhuysen and Pierrot, 2014). Lambot et al. (2017) suggest that the average annual temperature should range between 18 and 21°C, while Bote and Vos (2017) and Aceves et al. (2022) state that the optimal temperature for Arabica coffee is 17.1°C. Furthermore, in local studies conducted in the state of Oaxaca, Aragón (2016) and Ovando et al. (2017) mention that the average annual temperature for Arabica coffee crops should range between 17 and 21°C.

Moreover, according to scientific evidence, altitude and temperature are closely related (Bertrand et al., 2012; Aranda et al., 2014; Panhuysen and Pierrot, 2014). These variables have a direct and inverse relationship: for every 100 m of altitude, the temperature decreases by 1°C. This relationship determines that the most suitable climates for coffee cultivation are in mountainous regions with considerable altitudes (Bertrand et al., 2012; Kath et al., 2021). Buenaventura and Castaño (2002) suggest that altitude has a direct effect on the density, apparent swelling during roasting, and pH of the coffee bean. Apparent swelling refers to the increase in bean volume as a result of roasting and this value is influenced by altitude, peaking at 1,850 masl with an increase of 32.21%. Similarly, the bulk density of the grain increases with altitude, reaching a maximum of 0.72 g/mL at 1,650 masl. The pH of the soil decreases with increasing altitude, reaching a minimum of 1,550 masl. A turning point is observed at this altitude, marking a progressive increase up to 1,950 masl. The highest pH value was recorded at 1,850 masl, with an average of 5.072, while the lowest value was observed at 1,550 masl, reaching 4.964 (Buenaventura and Castaño, 2002). Lambot et al. (2017) argue that soil acidity should be within the pH range of 4.1–6.3 (Febrianto and Zhu, 2023).

The influence of soil properties varies according to criteria and location. In general, coffees with better cup quality are grown in soils with high levels of available phosphorus, potassium, clay, and silt. In addition, higher levels of soil pH, magnesium, manganese, and zinc are associated with improved coffee flavor. This effect suggests that soil quality is a critical factor in specialty coffee production and that the balance of different nutrients is essential to achieve the desired quality in the final beverage (Yadessa et al., 2020; Mojica et al., 2021).

3.3.2 Genetic factor

Genotype is a critical factor as it largely determines the size, shape, color, and chemical composition of beans, which directly affects their flavor and hence quality (Wintgens, 2004; Selmar et al., 2006; Gichimu et al., 2012; Cheng et al., 2016; Marie et al., 2020). For example, the morphology of beans (such as elephant, grain, pea, and empty beans) is influenced by both genotypic and environmental factors (Wintgens, 2004; Malau, 2020).

In coffee production, the terms 'robusta' and 'arabica' are commonly mistaken as varieties, when in fact they refer to the species *C. canephora* and *C. arabica*, respectively (Montagnon et al., 2012; Couto et al., 2019). The genus Coffea comprises more than one hundred species, each with a remarkable variation in chemical composition (Clifford, 1985). To date, *C. arabica* and *C. canephora* have been the most studied due to their commercial importance (Leroy et al., 2006). In Mexico, particularly in Oaxaca, *C. arabica* is the dominant species known for its high quality, especially in classic varieties like Caturra, Mundo Novo, and other pure lines obtained through pedigree selection (Aragón, 2016). Coffee from *C. arabica* is preferred over *C. canephora* because varieties of the robusta species are less aromatic and richer in caffeine (Leroy et al., 2006; Dessalegn et al., 2008; Kathurima et al., 2009; Kalschne et al., 2019).

Van Der Vossen (2009) points out that "Robusta blood" is often cited in the literature and the market as the cause of poor beverage quality. However, poor crop management, harvesting, and primary processing are often the main causes of low-quality crops. According to Kathurima et al. (2009) and Pruvot et al. (2020), buyers perceive the authenticity of *C. arabica* coffee varieties as a hallmark of high quality. DNA fingerprinting is considered a powerful tool for verifying the identity of different varieties. While the primary objective of breeding programs is to develop genotypes with improved coffee quality traits, advances in genomics provide new tools to analyze coffee quality at the molecular level (Tran et al., 2016). Yigzaw (2005) confirms that coffee quality is related to the genetic composition and the genes responsible for the production of aromatic compounds. Therefore, when selecting varieties for planting, it is crucial to prioritize geographical and environmental characteristics to determine the ideal variety (WeldeMichael et al., 2014; Borém et al., 2016).

An analysis conducted by Aragón (2016) of coffee varieties found in quality competitions, such as the Cup of Excellence and the Oaxaca Quality Award, revealed that although producers typically cultivate more than one variety in their fields, *C. arabica* Typica is the most prevalent variety in specialty coffee crops, accounting for 44%, followed by Bourbon at 14% and Caturra at 12%. Geisha, a variety of *C. arabica*, has recently gained recognition for its high-quality flavor profiles. An exceptional example is the Geisha coffee that set a world record at the Best of Panama event with a final price of USD data-idx = "2–1–2"50 per pound. Other Geisha varieties of coffee took second and third place, with prices of USD 170 each (Muñoz et al., 2015). Finally, it is recommended to Oaxacan coffee growers that when embarking on the production of high-quality coffee, variety selection is crucial. Certain varieties have been shown to achieve higher cup scores due to their genetic lineage. However, the grower must take into account the characteristics of the soil, climate, altitude, shade, light, and water availability (Decazy et al., 2003). In optimal environments, the quality potential of the variety can be maximized.

3.3.3 Agronomic factors and innovative post-harvest practices

Coffee bean quality is significantly influenced by the adoption of agronomic and post-harvest technologies and practices (Asfaw et al., 2016; Salengke et al., 2019). Several authors have suggested a strong relationship between environmentally friendly production systems and grain quality. They point out that agroforestry systems with a focus on sustainability not only promote environmental protection but also provide an ideal environment for maximizing grain quality potential (Bertrand et al., 2012; Panhuysen and Pierrot, 2014; Biswas and Biswas, 2015; Hernández and Nava, 2016). According to the International Coffee Organization (International Coffee Organization (ICO), 2010), a sustainable coffee production system improves soil stability and promotes biodiversity conservation in coffee-growing regions. An agroforestry system is based on sustainable crop and soil management. This system aims to continuously improve yields by integrating the cultivation of tree species with high-value crops such as coffee (Arcila et al., 2007).

Agroforestry refers to land use systems and technologies in which perennial woody species such as trees, shrubs, and palms, among others, are integrated into the same system of crop and/or livestock production in a spatial or temporal sequence (Nair, 1989). Among the characteristics of agroforestry systems, we can mention their extraordinary capacity to optimize production through diversified use. Trees play a crucial role in providing various products, such as timber, food, fodder, firewood, poles, and materials. Organic oils and resins, among others. On the other hand, trees are essential providers of services such as food security, soil conservation, shade, increased soil fertility, improved microclimate, living fences for crops and fruit trees, boundary demarcation, carbon sequestration, watershed stabilization, biodiversity protection, restoration of degraded lands, and weed control (Nair, 1989; Arcila et al., 2007; Bertrand et al., 2012). In coffee farming, an agroforestry system offers several benefits, including soil protection and improvement, natural fixation of various nutrients through crop rotation, shade trees for coffee plants, biological pest control, and the ability to obtain other associated products such as firewood, fruit, and honey. These benefits contribute to enhancing the quality of life for the farmers. Increasing the biological efficiency of the system helps to enhance the productivity of the coffee farmer (Arcila et al., 2007; Bertrand et al., 2012).

Pest and disease management is also critical. Pests and diseases can directly affect coffee cherry trees, resulting in immature or damaged fruit and lower-quality beans. Insects such as leaf miners and mites can cause this issue (Wintgens, 2004). However, Belay et al. (2016) argues against the use of pesticides in quality-focused coffee farms, while Biswas and Biswas (2015) advocate for integrated pest and disease management based on sustainable practices.

Coffee tree pruning plays a crucial role in determining the quality of coffee (Dufour et al., 2019), these practices focus on maintaining healthy and well-structured coffee trees to achieve high yields or rejuvenating old trees by pruning the trunks (Michiel et al., 2004). The main objectives are: (1) removing unproductive branches to avoid unnecessary competition for nutrients, (2) improving air circulation to prevent high humidity and fungal development, (3) facilitating access to the core of the tree for the application of agricultural inputs, and (4) reducing the risk of damage to the coffee tree canopy caused by heavy rain or wind. These practices apply not only to coffee trees but also to shade trees. The information regarding "geographical and climatic factors" indicates that agroforestry systems, which offer shade for coffee cultivation, create conditions that are favorable for enhancing the quality of the coffee bean. However, shade management and pruning are essential for controlling light exposure and the temperature of coffee trees (Dufour et al., 2019). Vaast et al. (2006) reported that excessive shade can reduce coffee tree productivity by up to 18% over three consecutive cycles. Therefore, they recommend a biannual variation, alternating between sunny conditions and controlled shade, to enhance productivity and quality. Trees that receive regular sunlight produce more fruit. Coffee trees prioritize the allocation of nutrients to the berries rather than the young parts of the branches, which determines the level of production in the following year (DaMatta et al., 2007).

In coffee tree nutrition, Aragón (2016) highlights the importance of starting with a soil analysis, followed by a foliar analysis to identify deficiencies and guarantee optimal fertilization adapted to the phenological stages of the crop (Bruno et al., 2011). In addition, Vinecky et al. (2017) suggests implementing controlled irrigation during dry periods and balanced fertilization with nitrogen (N), phosphorus (P), and potassium (K). These factors collectively influence the accumulation of biochemical compounds in coffee beans, which are crucial for improving beverage quality. Potassium treatment influences the biochemistry of the beans, affecting lipid and chlorogenic acid (CGA) content, while higher nitrogen levels contribute to increased caffeine levels.

In terms of harvesting and post-harvest effects on quality, handpicking is preferred to mechanical harvesting. Handpicking allows the selection of suitable beans and results in the highest quality green coffee by minimizing defects in coffee lots (Leroy et al., 2006; Poltronieri and Rossi, 2016). Harvesting only ripe coffee cherries is crucial, as green, unripe, overripe, and over-dried cherries on the tree are considered of inferior quality and should be separated (Rien, 2016). Sorting takes place at every stage, even after harvesting. Both dry and wet methods are used to extract the bean from the pulp. In Oaxaca, the wet method is the most common for Arabica coffee. This method increases the coffee's acidity, which interacts with its body and enriches its flavor (Rien, 2016; Shen et al., 2023).

Moisture content is a critical factor in determining quality. High moisture content in kernels can result in physical and sensory losses and defects (Leroy et al., 2006). If the moisture content exceeds 12.5%, the kernels may develop mold during storage. If the moisture content is below 8%, the coffee loses its aroma. This factor affects the roasting process and weight loss during roasting. Low-moisture beans roast faster than high-moisture beans (Leroy et al., 2006; Tarigan et al., 2022).

Jute bags are traditionally used to store green beans. However, Borém et al. (2013) conducted a study to evaluate the effect of storage material on coffee quality. They used hermetic bags, hermetic bags with carbon dioxide (CO_2) injection, and jute bags. The results showed that beans stored in hermetic bags with CO_2 injection maintained a specific coffee quality. The hermetically sealed bags without CO_2 injection preserved the desired aroma, whereas the coffees stored in jute bags showed a low frequency of attributes such as sweetness and acidity, as well as undesirable flavors and aromas.

Finally, based on the review of research in the section on agronomic factors, this work proposes a list of the key activities identified in the production process that have the most significant impact on the quality of the coffee bean and the cup:

1. Design of the agroforestry system on the plot.
2. Choice of coffee variety according to environmental conditions (geographical and climatic).
3. Soil and leaf analysis.
4. Optimize fertilization based on analysis findings and provide nutrition that corresponds to the phenological stage.
5. Management and regulation of shade trees.
6. Pruning (training, rejuvenation, and health).
7. Pest and disease management.
8. Selective manual harvesting using maturity criteria (grape color, size, and Brix values).
9. Choice of method for extracting the coffee bean from the pulp.
10. Drying on clean surfaces and not exposing the coffee directly to the sun to protect the embryogenic activity (use of shade nets).
11. Monitoring the humidity level during the drying process (11.5–12° humidity).
12. Grading and quality control.
13. Optimum storage conditions (airtight bags).

3.4 Processing factors

Once the beans have been harvested and prepared, their sensory quality is influenced by processing, mainly by roasting (Sualeh et al., 2014). This process has been rigorously studied by several authors, such as Clarke and Macrae (1987), Illy and Viani (2005), Schenker et al. (2000), and Yeretzian et al. (2012), and is generally defined as a dry heat treatment. There are several methods of roasting, the most common of which is the use of hot air. During this process, the increase in temperature causes extensive chemical reactions, dehydration, and significant changes in the microstructure of the beans. These changes result in the development of complex flavors that can be extracted into the final beverage, resulting in very high-quality cups of coffee. The primary goal of roasting is to produce coffee with the desired flavor, dark color, and porous, brittle texture that is optimal for grinding and extraction (Schenker and Rothgeb, 2017). The combination of temperature profile and roasting time determines the perceived aromas and flavors in the beverage (Leroy et al., 2006). However, roasting affects aroma, flavor, bitterness, and acidity. At least 600 new volatile compounds are formed during this process, which influence the aroma (Rien, 2016).

According to Sualeh et al. (2014), the optimal roasting time for Arabica coffee should be 10 min at a temperature of 200°C, followed by rapid cooling to halt the cooking process (Fernandes, 2019). Schenker and Rothgeb (2017) suggest that the beans must reach a temperature of at least 190°C for a certain period to initiate the chemical reactions characteristic of roasting (Chindapan et al., 2019). The traditional coffee roasting process involves a gradual increase in temperature until it reaches its peak, followed by rapid cooling to stop the process. Roasting is a crucial operation and the final opportunity to enhance coffee quality and determine the physical properties of the beans (Rien, 2016; Schenker and Rothgeb, 2017).

3.5 Socio-economic and commercial factors segment

3.5.1 Commercial factors and market strategies

We have already explored the marketing of premium coffees and found that it offers an alternative to the price crisis. Specialty products are valued for their unique flavor characteristics, production methods, marketing approach, and origin, which can be as specific as the name of the farm. This uniqueness makes specialty coffees more lucrative for producers (IICA-CIATEJ, 2016; Velásquez and Trávez, 2019). Ensuring product traceability is crucial for maintaining competitiveness in this market and meeting consumer demands. This can only be achieved by understanding, controlling, and managing all the factors involved in the process (Escamilla, 2012). Once this control has been achieved and a high-quality specialty coffee has been produced, important questions arise: How will it be marketed? What will be the distribution channel? What price will it be sold at? These commercial aspects are crucial for producers to enter this market niche.

As explained above, high-quality specialty coffees are not tied to the price of regular coffee, which is determined by the New York Stock Exchange. The value of the products is established through negotiations between the customer and the supplier and is influenced by the product's quality (Oficina de Estudios Económicos y Estadísticos, 2013; Muñoz et al., 2015; Aragón, 2016; Figueroa et al., 2019). Therefore, these niches tend to be exclusive or limited to certain producers by adopting a business model that eliminates intermediaries and relies on direct negotiations (Geels, 2002). Wollni and Zeller (2007) argue that these specialized markets tend to exclude small producers.

An example of this commodification occurs when multinational corporations enter communities and enforce their guidelines and private standards initiatives, which are promoted through certifications such as Rainforest Alliance, UTZ Certified, 4C, and C.A.F.E. Practices. These certifications are used by processors like Starbucks, Sara Lee, Nestlé, and Kraft (Muñoz et al., 2015). These multinational corporations (MNCs) engage in direct private agreements with producers and assume responsibility for the entire marketing process if the producer meets their established quality standards. Nevertheless, we find that this marketing method encourages individualization, as the transaction becomes a direct deal between the multinational and the producer, and the prices paid to producers for the quality of their coffee are generally unfair.

In response to this situation, strategies have been developed to facilitate producers' participation in the market. One such strategy is the auctions organized by the Specialty Coffee Association of America (SCAA) during its "Cup of Excellence" events, which are held annually at various locations around the country. At these events, small batches of coffee are presented and evaluated by international judges using the SCAA scale and then auctioned worldwide via the Internet. The buyers are baristas and gourmet shop owners, many of whom are from Asia, particularly Japan, Taiwan, and Korea. They are followed by buyers from the United Kingdom, the United States, and Australia who are looking for unique, high-quality coffees from specific origins (Amecafé-ACE, 2019).

At the state level, in Oaxaca, the Centro Regional Universitario Sur CRUS-Chapingo has been organizing the Oaxaca Coffee Quality Award since 2014. This initiative has attracted the participation of state, national, and international buyers, promoting this form of production and marketing in the state. However, the list of winners does not exceed 15 producers per edition. This suggests that while it serves as a platform for marketing, promotion, and prestige, it has yet to fully represent the productive potential of the state. Ang (2011) suggests that a "strategic chain orientation" can influence market dynamics. This approach involves a series of collaborations initiated by a product agent to achieve a common goal. In volatile markets, collaborations have been found to outperform other firm approaches, and the resulting feedback generates a series of self-perpetuating events (Lenton and Scheffer, 2024).

Barrios et al. (2016) propose that the adoption of collective marketing strategies can catalyze the well-being of stakeholders and farmers. This involves establishing a framework of market-based transformation mechanisms through associations that contribute to empowerment, communication, community building, and regulation. Furthermore, Abaunza (2011) and Velásquez and Trávez (2019) argue that specialization processes in production lead to changes in the productivity of coffee farmers. According to Kim et al. (2012), these changes in collective production processes typically lead to improved efficiency and profitability. For this reason, this research suggests that it is possible to consider community exercises as a viable alternative for small coffee producers in Oaxaca through standardized production and daily market transactions.

3.5.2 Socio-economic factors

The adoption of improved agricultural practices by farmers depends on their ability to access, process, and use information on advanced technologies (Belay et al., 2016). Kasim (2012) emphasizes the strong connection between knowledge diffusion and the adoption of new technologies. Furthermore, Bacon (2013) observes that knowledge diffusion is associated with increased interaction and communication among social actors such as producers, buyers, and other chain participants, which can accelerate the adoption of innovations. However, Aldaz (2022) and Mohammedshum et al. (2023) observe that technical, socioeconomic, and institutional factors have limited the adoption of technologies. In the section on agronomic factors and innovative practices, it was noted that specialty coffee producers face varying investment costs. The financial situation is one of the main obstacles to entering the specialty coffee production industry (Aragón, 2016; Aldaz, 2022). Specialty coffee production costs are typically 40% higher than conventional processes, mainly due to increased labor costs, especially in harvesting and wet and dry processing (Aragón, 2016). Neilson (2007) notes that quality in the specialty coffee sector is increasingly dependent on traceability systems. However, the costs associated with these systems can be high and are often beyond the reach of small producers, contributing to their exclusion from the quality building process (Dilas et al., 2020). Coffee is a crucial crop in Oaxaca, but producers believe they have limited or no access to credit (Aragón, 2016). The lack of tailoring to coffee producers' context and situations could explain this non-compliance with requirements. According to Aragón (2016), restructuring institutional credit is necessary, considering the characteristics of the productive sector.

Vanderhoff (1987) and Hernández (1992) reported that in the 1980s, coffee production in Oaxaca underwent significant social and organizational restructuring due to changes in public policy, such as the closure of INMECAFÉ and the transition to a free market. Faced with the productivity and commercial crisis caused by this new economic model, coffee farmers in the southern coffee regions of the country, particularly in Oaxaca, have organized collectively (Vanderhoff, 1987; Hernández, 1992; Bartra et al., 2011; Sánchez, 2015). This organization was crucial for many producers, especially smallholders, and became their "salvation" over time. These organizations have adapted to government policies in the coffee and agricultural sectors (Hernández, 1992). Participation in organizations and producer cooperatives has been shown to positively influence the decision to grow specialty coffee and the prices farmers receive (Tolessa et al., 2018). It is also associated with access to information on production and market innovations (Wollni and Zeller, 2007; Tran et al., 2023). The study by Tolessa et al. (2018) examined the impact of cooperative membership and standardization of methods on the quality of Arabica coffee. The research found that coffee beans from cooperatives received higher quality scores and were classified as specialty coffee. This was attributed to knowledge sharing and the implementation of standardized practices within the organization.

The study by Chávez and Natal (2012) examines the factors that enable impoverished, undereducated farmers who are marginalized by markets and government to succeed in global markets. They emphasize the importance of forming alliances with different stakeholders and using these connections to enhance their capabilities. Osterwalder and Pigneur (2010) emphasize the importance of maintaining "key partnerships or alliances" to mitigate risks. Therefore, in a context where 64% of producers are considered smallholders (Becerra, 2013; Fideicomisos Instituidos en Relación con la Agricultura – FIRA, 2014), it is essential to consider the importance of producers being part of organizations and the collective benefits they offer, such as information sharing, quality standardization, and access to global and specialized markets. For this reason, in this article, we review different forms of successful organizational models for small coffee producers. We have discovered that strategies are emerging from the farmers' own experiences to resist the conditions and impacts of the free market. These small producer initiatives aim to build a "dignified and sustainable" economy (Collin and Barkin, 1997; Barkin, 1998; Collin, 2008), "community" (Esteva, 1994; Toledo, 2000), and with a focus on "community-based enterprise" (Peredo and Chrisman, 2004; Donovan et al., 2008).

Peredo and Chrisman (2004) define the concept of a Community-Based Enterprise (CBE) as "a community that acts collectively as a company in pursuit of the common good." Donovan et al. (2008) added that agroforestry enterprises are businesses focused on producing agricultural or forestry products and services. These enterprises are owned by small producers and have various goals, including participating in global markets. These community enterprises include specialized food and agricultural products and high-volume, low-value segments where competition tends to be fiercer, such as coffee (Donovan et al., 2008). Toledo (2000) proposes five pillars of sustainable community enterprises: (1) defense of traditional cultural values, (2) maintenance and/or reproduction of the community structure based on equity among community members and consensus through the community assembly, (3) high technological and administrative efficiency, (4) collective control of economic processes and exchanges based on a specific "productive balance," and (5) conservative use of natural resources. Therefore, this review article proposes CBEs as a viable and sustainable option for small-scale producers in Oaxaca to organize themselves and gain access to the high-quality specialty coffee market. Together, they will be able to resist the decline in coffee prices, the constant volatility, and the structural changes in the market.

3.6 Matrix of factors for the production of high-quality specialty coffee G.G.A.P.C.S

As a result of the thorough review and analysis of the 138 scientific documents, we identified and classified 6 main factors that intervene in the production of high-quality coffee and in the insertion process of small producers to the specialty coffee market: 1. Geographical and Climatic Factors, 2. Genetic factor, 3. Agronomic factors and innovative post-harvest practices, 4. Processing factors, 5. Commercial factors and market strategies y 6. Socio-economic factors. With this information we formulate a matrix of factors for the production of high-quality specialty coffee, the "G.G.A.P.C.S. Matrix" (Table 3). The aim is to help small producers consider the factors involved and adopt the necessary activities to achieve their transition.

Also, we designed an illustration of the key activities in the specialty coffee production process as a guide (Figure 2), It outlines the steps that a conventional coffee producer, particularly from the "small producer" category, must take to transition from conventional to specialty coffee production. We highlight the importance of producer associations for achieving collective standardization of production quality and insertion into specialized market transactions.

4 Conclusion

Once we identify in the literature review that the high-quality specialty coffee market is an opportunity and a profitable alternative to avoid specific problems in the coffee sector, we throw the question: How can we achieve the integration of small coffee growers in Oaxaca into specialized markets? This led us to the objective of this systematic literature review: to identify the factors involved in integration of small coffee producers into specialized markets in Oaxaca, Mexico.

We found that the transition from traditional to specialized producers is a complex process that necessitates traceability systems, from production to consumption. This research identified 6 main factors classified into 2 segments: agro-environmental and socio-economic. In the first segment concerning agro-environmental factors, we confirm that climate and geography are crucial in determining specific characteristics, as the environment strongly influences coffee quality.

Altitude, temperature, rainfall, and soil characteristics are key factors. This review has identified that the ideal temperature range in Oaxaca is 17–21°C, and the optimal altitude range for producing high-quality coffee is between 1,200 and 1,650 masl. These will be the first factors that a coffee grower aiming to produce high-quality coffee will need to consider and verify that their farm meets the necessary conditions. We recommend that small producers at lower altitudes prioritize strategies to increase the productivity of conventional regular coffee, while those at higher altitudes should concentrate on improving quality.

Subsequently, next, when considering genetic characteristics, it is crucial to choose a suitable genetic variety that aligns with geographical and climatic factors. In terms of agronomic practices (Table 3), innovations in production, harvesting, and post-harvesting

TABLE 3 Matrix of GGAPCS factors for the production of high-quality specialty coffee.

Geographical and climatic	Genetic
■ Geographic location ■ Altitude and temperature ■ Precipitation distribution ■ Soil physicochemical conditions and pH ■ Shading	■ The genotype is selected based on the soil characteristics, climate, altitude, shade, availability of light, and water
Agronomy and innovative post-harvest practices	**Processing**
1. Agroforestry system design – sustainable practices. 2. Choice of coffee variety according to environmental conditions (geographical and climatic). 3. Soil and leaf analysis. 4. Optimal fertilization based on the results of the analysis and nutrition according to the phenological stage. 5. Shade tree management and regulation. 6. Shade management and pruning. 7. Selective manual harvesting based on maturity criteria (color, size and Brix). 8. Choice of method for extracting the coffee bean from the pulp. 9. Drying on clean surfaces and avoiding direct exposure to the sun to protect the embryogenic activity (use of shade nets). 10.Monitoring the humidity level during the drying process (11.5–12° humidity). 11.Classification and quality control. 12.Optimum storage conditions (airtight bags).	■ Roasting control ■ Define the temperature profile and roasting time-based on the specific characteristics of each sample, to maximize attributes such as aroma and flavors perceived in the beverage.
Commercial and market strategies	**Socio-economic**
■ Shortening the chain of intermediaries facilitates direct customer-supplier negotiation. ■ Participation in high-quality competitions ■ Collective marketing strategies ■ Quality Standardization for the Collection of Lots and Micro lots ■ Submitting coffee for cupping to obtain certificates that guarantee the quality of the harvest is essential for promoting the product ■ Define pricing policies based on quality ■ Purchase and sales agreements or contracts with prospective customers	■ Dissemination of specific information on production and market innovations ■ Collective activities, negotiations, and access to finance ■ Participation in associations, cooperatives, and specialized production networks, Proposal CBE ■ Standardized production through community collective models ■ Collective control of economic processes and exchanges based on a certain “productive balance” ■ Collective awareness of the appropriate and efficient use of natural resources

are essential to ensure coffee quality. This includes appropriate fertilization based on soil conditions, integrated pest and disease management, selective harvesting of cherries at their ideal ripeness, and a thorough post-harvest process.

Once this unique quality of coffee is achieved, the question of commercialization and the socio-economic factors involved arises. Since specialized market transactions require specific quality and quantity conditions, this article proposes the formation of associations of small coffee producers based on a sustainable community approach. The approach emphasizes equity among members and a productive balance while ensuring the protection of natural resources. The CBE model is proposed as a viable and sustainable option for small producers in Oaxaca to organize themselves and enter the high-quality specialty coffee market.

Finally, this research suggests that subsequent studies work on the following knowledge gaps:

1 Thoroughly identify the social, political, economic and cultural factors in the state of Oaxaca, which intervene in the process of transition from conventional to high-quality specialty coffee.
2 Work on the design of relevant public policies considering the characteristics of the state, the areas and potential producers and the factors necessary for the production of high-quality coffee that are identified in this review.

Author contributions

SA-G: Writing – review & editing, Writing – original draft, Visualization, Resources, Project administration, Methodology, Investigation, Formal analysis. JR-M: Writing – review & editing, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation. AV-L: Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Methodology, Investigation, Conceptualization. AT-L: Writing – review & editing, Writing – original draft, Visualization, Supervision, Software, Resources, Project administration, Methodology. SN: Writing – review & editing, Supervision, Software, Resources, Project administration, Methodology. CG-E: Writing – review & editing, Writing – original draft, Visualization, Supervision, Software, Resources, Project administration, Methodology, Formal analysis, Data curation. NL-V: Project administration, Methodology, Writing – review & editing, Visualization, Validation, Supervision, Software, Resources. FA-B: Writing – review & editing, Visualization, Validation, Supervision, Software, Resources. BQ-G: Writing – review & editing, Validation, Supervision, Software, Resources, Project administration, Methodology. JP-R: Writing – review & editing, Visualization, Validation, Supervision, Software, Resources.

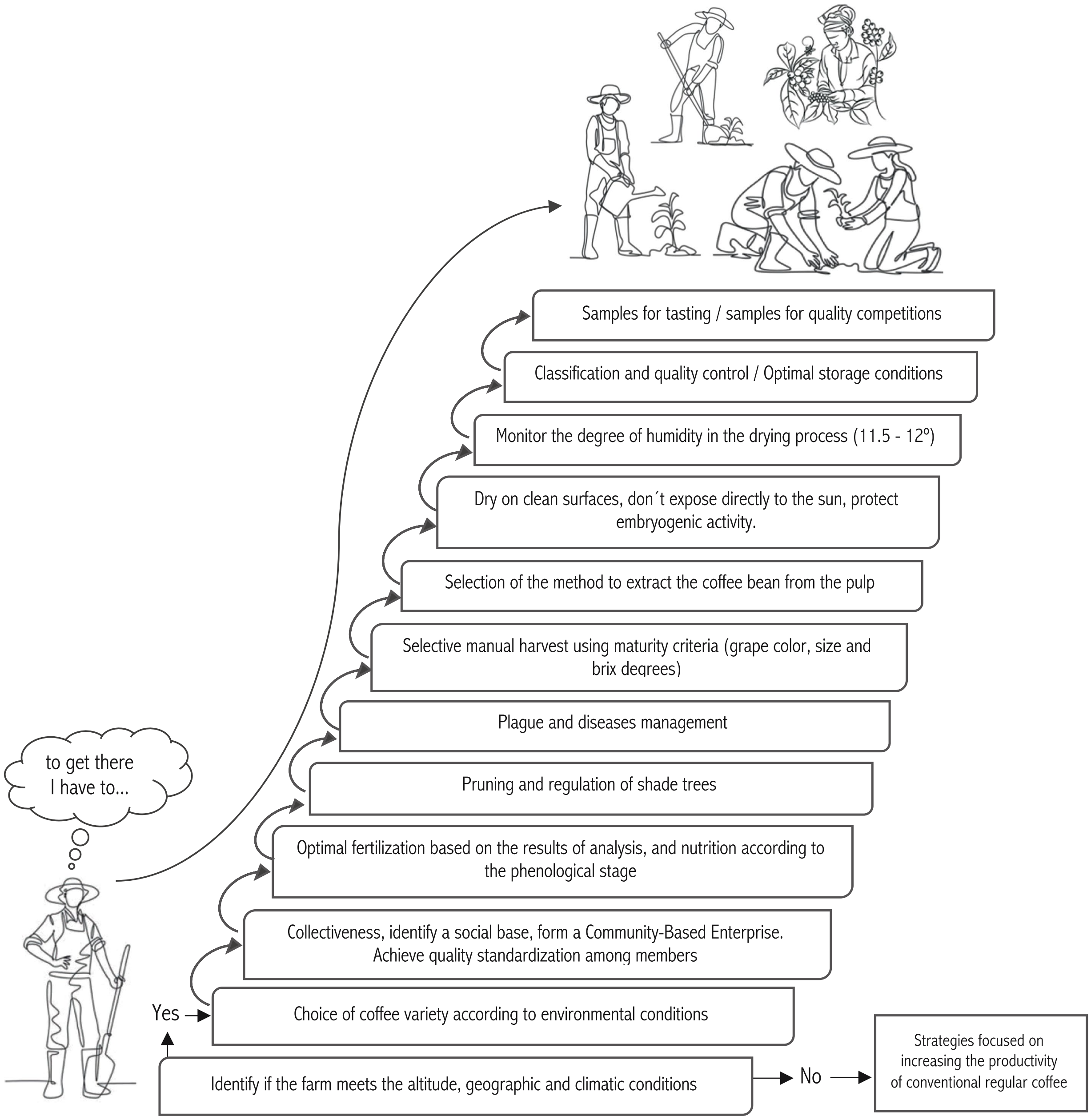

FIGURE 2
Key activities for the production of specialty coffee, as a guide.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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