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Ethnobotanical survey and commercial trends of medicinal species in Colombian Andes

MASTER'S THESIS

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Declaration

I hereby declare that I have done this thesis entitled Ethnobotanical survey and commercial trends of medicinal species in Colombian Andes independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In Prague 15.4.2023

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Zuzana Rázková

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Abstract

As one of the world's biodiversity hotspots, the Colombian Andes are home to many different plant species, including those used in traditional medicine. These species provide health and security to local communities bearing traditional knowledge associated with their use for centuries. One of the places where plant diversity and cultural knowledge meet are local markets. However, little is known about the complexity of medicinal plants market chains. Therefore, this study focused on ethnobotanical and socio-economic research in five Colombian Andean cities. It aimed to (i) identify the most commercialised species and their geographical origin, (ii) explore the use and economics of three pre-selected local species, and (iii) examine the socio-economic background, marketing challenges and knowledge of medicinal plants among vendors. A total of 30 vendors were interviewed in the five study sites. Altogether, 55 medicinal species belonging to 30 botanical families were identified as the most commercialised ones. Of these, 71% were introduced, and five species were native to the Colombian Andes. Three preselected species *Equisetum bogotense* , *Myrcianthes leucoxyla* and *Juglans neotropica* were sold for 13 usage categories. The highest agreement, based on the Informant Consensus Factor (ICF), was found for food (ICF=1), endocrine system (ICF=0.98) and urinary system (ICF=0.97). The highest Use Value (UV=2.40) and Informant Agreement Ratio (IAR=0.90) obtained *Equisetum bogotense*. The *E. bogotense* was the most profitable, with the most frequent daily margin of COP 2,000. However, *M. leucoxyla* generated the highest profit per amount sold (COP 3,600). Majority of vendors (83%) were selling herbs as their primary occupation and 73% acquired knowledge from their family members. After the Covid-19 pandemic respondents reproted increased attention from customers (37%) and medicinal plants sales (59%). These findings should help the goverment and other stakeholders to support the market chain development of medicinal plants in Colombia through for example inclusion of youth collectors and traders and support of sustainable harvesting of local species.

Key words: bio-cultural diversity, market chain, quantitative ethnobotany, vendors, traditional knowledge

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IAR	Informant Agreement Ratio
ICF	Informant Consensus
IUCN	International Union for Conservation of Nature
UR	Use Report
UV	Use Value
WHO	World Health Organization

1. Introduction

Since ancient times, medicinal plants have played an essential role in the development of human civilisation. To this day, medicinal plants have been used to treat various ailments and illnesses, infections, reduce pain, improve sleep and enhance overall health (see e.g., Lulekal et al. 2008; Máthé 2015; Assefa et al. 2020). Even many pharmaceutics still use extracts from natural sources (Chen et al. 2016; Navia et al. 2021).

Although the collection and utilisation of medicinal herbs is a worldwide phenomenon, some places with a higher diversity of species indicate the possibility of a higher abundance of species that can be used against various diseases and health complications. This is why ethnobotany evolved and why does it have nowadays major focus on biodiversity hotspots which hold a primary role in hosting different medicinal plants due to the immense diversity of fauna and flora that they keep (Lulekal et al. 2008; Dunstan et al. 2012; Behailu & Temesgen 2017; Paniagua-Zambrana et al. 2020). Therefore, the societies living nearby such places are expected to embrace valuable knowledge about medicinal plants and one of the places where this understandings can be distributed are traditional markets. In these places the herbalist or vendor is passing the knowledge, skills, traditions and practices through generations and teach about plants' usage, dosage, storage, cultivation or collection of particular medicinal plant part (Idu et al. 2010; Giraldo Quintero et al. 2015; Lima et al. 2016; Bussmann et al. 2018b; Osawaru & Ogwu 2020).

One of the most important hotspots in the world is the Andes, located in the Andes Mountain range in South America (Bystriakova et al. 2021; Comer et al. 2022). It is recognised as one of the world's most diverse regions, covering approximately 1.38 million square kilometres, with different ecosystems such as montane forests, grasslands, wetlands, and high-altitude habitats. In Colombia, most of the population is extended throughout the Andes region, meaning that the interaction between society and the ecosystem is a daily activity. Therefore, preserving traditional knowledge and cultural heritage in terms of the usage of medicinal plants must be firmly carried out (Paniagua-Zambrana et al. 2020; Ángel-Bravo 2021).

Nevertheless, despite various studies documenting markets ((Lima et al. 2016; Bussmann et al. 2018a; Petrakou et al. 2020), value chains (Van Hoyweghen et al. 2021;

Mpelangwa et al. 2022) and vendors (Alves da Silva et al. 2014; Tinitana et al. 2016; Schupp et al. 2021) there is limited literature on socioeconomic aspects of herbal medicine marketing in biodiversity hotspot of Colombian Andes. Therefore this thesis specifically aims (i) to document the major commercialised medicinal plant species in Colombian markets within the Andean region, (ii) further evaluate how three pre-selected species of local origin fare in the markets and what is their importance for citizens, vendors and traditional medicine, and lastly, (iii) to describe the economic significance of the three pre-selected species and to present vendors' socioeconomic and knowledge background. This could provide valuable data to further our understanding of the interconnectedness of local nature and the people.

2. Literature review

2.1. Medicinal plants for human health

Medicinal plants are considered an essential part of our lives. As we evolved, our understanding of medicine and homoeopathic substances grew within us. Although modern awareness supports the "conventional" way of healing, 80% of the Earth's population still depends on herbal medicine as a primary source of medicine for different treatments; thus, it irreversibly forms a base of the global health care system. These matter mainly apply for developing countries, where medicinal plants represent a more achievable way of health care (Burton et al. 2015; Chen et al. 2016; WHO 2019).

Over 70,000 medicinal plant species are used, accounting for 17% of known plant species (Miththapala 2006). The high diversity reflects the unique biological and cultural variety worldwide and holds together different traditions and histories of particular places. Also, the biodiversity and wide offer of plant species in developing countries, which are mainly located in the tropics, account for the large socioeconomic and cultural dependance of the societies on medicinal plants (Miththapala 2006; WHO 2019).

Back in the time, 5,000 to 6,000 years ago, people gathered plants from the wild without understanding their specific properties, which affected their health. Nowadays, we use agriculture and scientific knowledge to use cultivation practices and to find out about the plants' biological compounds to affect the healing effect in the human body (Máthé 2015; Tiwari & Rana 2015). Plants' bioactive compounds are completed from secondary metabolites that ensure survival in an unfavourable environment (Ashraf et al. 2018; Yang et al. 2018). The more challenges the plant faces during its life, more secondary metabolite compounds are produced. Thus, in tropical areas, the climatic conditions allow higher environmental pressure and variation than in temperate zones (thanks to ecosystem diversity), and plants grow in an adverse environment, hence more effective compounds are produced (Salazar et al. 2018; Ramawat 2019). This phenomenon can be seen in highly diverse environments such as in "biodiversity hotspots" (Mili et al. 2021).

2.2. Biodiversity hotspots as a “pool” for herbs diversity

With an increasing species extinction, more scientists are focusing their research on places with a higher number of endemic species. Biodiversity hotspots covering 2.4% of Earth (Hrdina & Romportl 2017) have two main pillars given by Myers et al. (2000). The area of a "hot spot" must include at least 1,500 endemic vascular plants and at minimum 30% of the vegetation must be primary (Myers et al. 2000; Venter et al. 2016). They are irreplaceable, meaning that the life found in these places is not available in any other place in the world, they can offer us solutions to different of our problems, not only materials or substances for more sustainable living such as fabrics or fibres produced from different plants or even oils from plant based products, but also new bioactive compounds that could eventually answer as a cure for a yet untreatable illnesses (Dunstan et al. 2012; Khan & Cundill 2019). Found in tropical and subtropical regions biodiversity hotspots consist of 25 regions, see Figure 1 (Myers et al. 2000; Spicer 2017; Harvey et al. 2020). Mayers et al. (2000) presented the five most important biodiversity hotspots: Madagascar, Sundaland, the Brazilian Atlantic Forest, the Caribbean and the Tropical Andes.

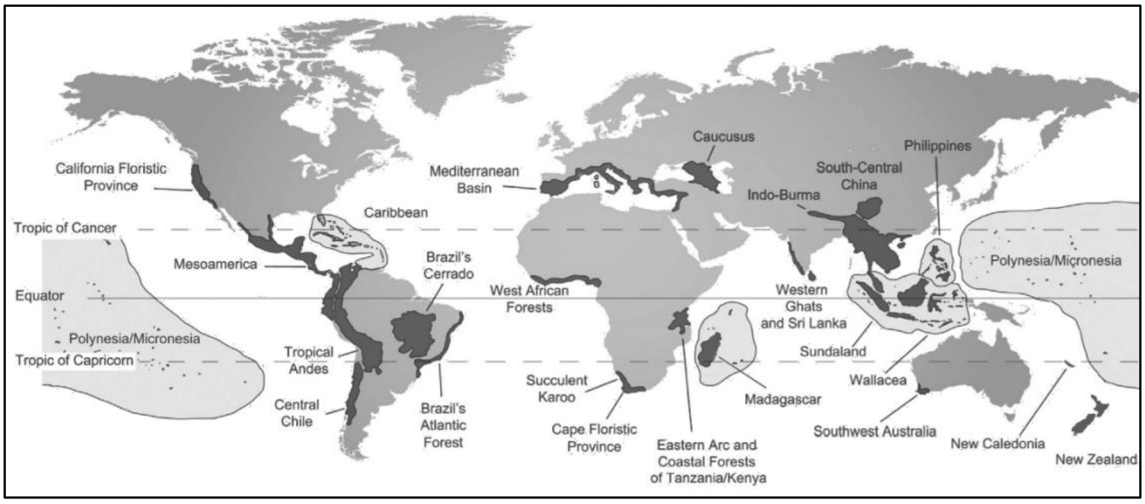


Figure 1. The 25 biodiversity hotspots based on Mayers et al. (2000)

Source: Spicer (2017)

Scientists started to perform research in these areas concerning finding unknown or underutilised plant species. Many studies have been published and the literature holds diverse research that display the proof of high biological diversity and reasoning for the conservation of these places depending on their primary focus (Mejía-Falla et al. 2020; Zwiener et al. 2021; Flury et al. 2021; Comer et al. 2022; Fulgence et al. 2022). Since the

significant areas belong to developing countries, there is rising a question related to the biodiversity richness, and how it reflects the socioeconomic status of local inhabitants. Nonetheless, this question is still somehow unanswered since recorded literature and articles mainly deal with the biological importance and the socioeconomical impact is left aside. Because of the scarce information about its economic effect on local communities, it is relevant then to understand and reflect on the link between society and the influence their surrounding hotspot inflects on it (Lima et al. 2016; Bussmann et al. 2018b; Marmolejo Liloy et al. 2018).

One of the most valuable biodiversity hotspot rich in medicinal plants is Andean mountainous range including Colombia. With over 50,000 plant species, Colombia is the second most diverse country in the world (WWL 2017; Kattan et al. 2004). The country is built from six central bioecological regions: The Caribbean, The Pacific, The Andes, The Orinoquía, The Amazon and Islands (Figure 1). Each of them holds its own characteristics that differ from one other. The richest bioregion is the Andean one, which contains more than 15,500 vascular plant species (Rangel 2015; Paniagua-Zambrana et al. 2020; Bystriakova et al. 2021). The South American Andes rise as one range from Argentina along the continent's left edge up to the Colombian border with Ecuador, where they split into three different mountain ranges ending in northern Colombia and Venezuela. In Colombia, the Andean bioregion consists of three mountain ranges: Western, Central and Eastern. These ranges allow two central valleys to form (Cauca and Magdalena Valley), running from south to north, correlating in height from 500 to 5,400 m asl, giving the region a more significant opportunity for diversity since it contains large number of different ecosystem types as seen on Figure 2 (Rodríguez Eraso et al. 2013).

The Andean region is the most populated in Colombia, concentrating up to 70% of the country's population with significant economic activity since most of the major cities are located in this region (Rodríguez Eraso et al. 2013). Away from the economic status of the Andes, this region is also home to many tribes of indigenous people who hold vital knowledge and skills related to medicinal plants and to the nature that surrounds them, their understandings are unfortunately slowly being forgotten (Archila et al. 2020). Over 26% of Colombian indigenous people live in the Andes, bearing the overlooked information on curative florae we nowadays seek aside from many others, also the cultivation of medicinal plants (Sichra 2009).

Thanks to their traditions, we can still find diverse varieties of medicinal plants, ointments, oils and others preserved and shared with the new generations as ethnobotanical knowledge and awareness of traditional medicine (de Carvalho Nilo Bitu et al. 2015; Ángel-Bravo 2021). The place where traditional indigenous knowledge is connected to socioeconomic activity is the local market, offers a relationship between nature, culture and economy.

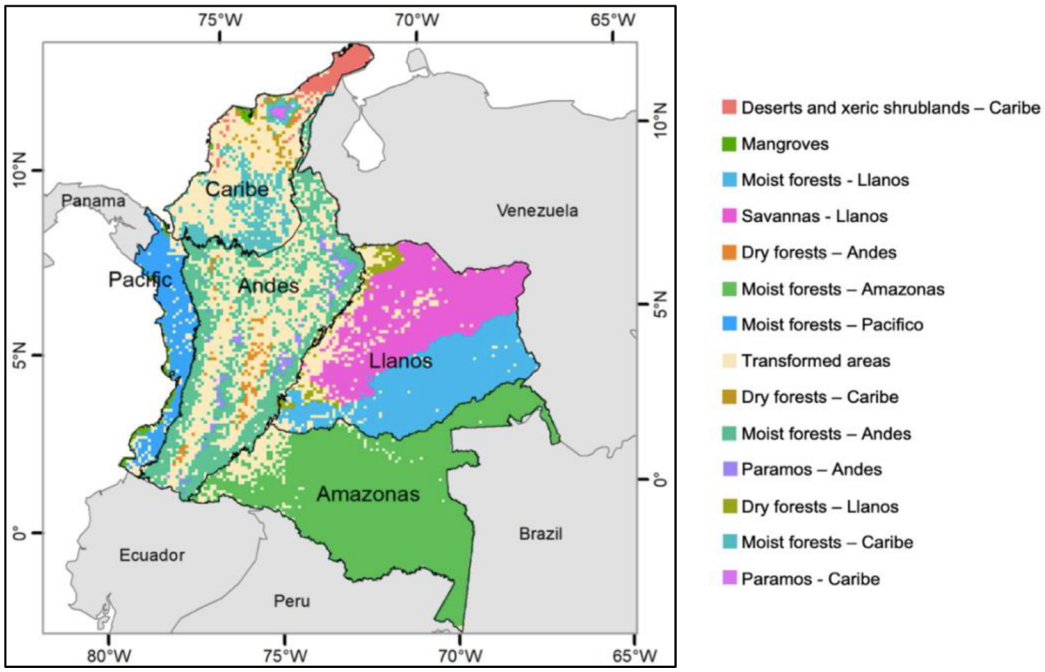


Figure 2. Bioregion map of Colombia.

Source: Bystriakova et al. (2021)

2.3. Local marketing of medicinal plants

Places serving to exchange products produced, harvested, and collected in the given area are called local markets. They exist since ancient times and have been essential to human society (Bromley 1971). Generally, trading goods provided people with more opportunities to improve their living standards by selling, buying, or exchanging goods. Therefore, the product amount and diversity available in the market reflect the development status of the given area (Basil 2012). Being of a dynamic character, these markets evolved to satisfy local demand, and the base of socio-cultural background conditions remained the same. Local markets represent places where trade and social

relationships evolve and even bringing rural and urban areas of a region (Monteiro et al. 2010; Baracaldo Huertas & Becerra 2019). People gather here for products of local origin; food (fruits, vegetables, meat), household goods, clothes, handcrafts, or plants with medicinal properties (Utami et al. 2018; Osawaru & Ogwu 2020). By buying the products, the vendor also shares knowledge and life experiences; thus, getting to know the trade of a specific area could offer us more understanding of the identity and diversity of the place and therefore the country's cultural variety, which are somehow still preserved in each one of these markets. Among others, expressions of faith and society remain here as a tribute to indigenous history and traditions (Ángel-Bravo 2021). These days traditional understandings have been slowly pushed aside by new technologies, standardisation, and regulations; therefore, there is little time to gather and summarise the information these places hold.

In order to obtain a greater understanding of the global trade of medicinal species in markets, various studies have been done displaying the variability of species as market ethnobotanical surveys (Macía et al. 2005; Lee et al. 2008; Idu et al. 2010; Petrakou et al. 2020). Aside from the ethnobotanical description of the species in certain regions, markets offer to exhibit the value chain analysis of goods and how these products affect the household economy, life development and improvement (Fonseca et al. 2020; Soullier et al. 2020; Mpelangwa et al. 2022). Studies about such a subject go deeper into the source of product origin in order to comprehend cost behaviour and distinguish existing potential sources of differentiation of the trade. In recent years were found studies regarding the impact of Covid 19 on the trade of medicinal plant species as a trend to treat the disease (Arouna et al. 2020; Gereffi 2020; Van Hoyweghen et al. 2021).

In Colombia, medicinal plants are frequently sold in marketplaces called "galerías" or "plazas de mercado", which display the authentic Latin-American traditions and identity, placed in the heart of the cities offering all kinds of goods (Ángel Bravo 2016). It is a place that expands conventional healthcare and where people from different social and cultural backgrounds come for help at their discretion (Garzón Chiriví 2018).

Medicinal plants sold in the markets greatly vary even within one city. Bussmann et al. (2018) disclosed that in 24 markets in Bogotá was high multiplicity between plant species, probably for its diverse population; therefore, it is expected that different cities in Colombia will find a different assortment of herbs specialised for the treatment of local illnesses and conditions. Although still little studies are done regarding this subject.

2.4. Colombia as study site and current trends

Colombia, being one of the world's most biodiverse countries, is gaining recognition for its extensive traditional knowledge of medicinal plants, attracting the interest of numerous researchers.

The beginning of the botanical studies dates from 1760 to 1816 when José Celestino Mutis, under the "Royal Botanical Expedition of the New Kingdom of Granada", began to research about pre-Colombian ethnobotany including plants with pharmaceutical purposes in the Colombian Andean region (Paniagua-Zambrana et al. 2020). Throughout the years, the Colombian ethnobotany faced many upturns, such as for the study of narcotic and stimulant plants (Nestor Uscategui 1959) but also criticism concerning the oppression of indigenous tribes (Paniagua-Zambrana et al. 2020).

Many years have passed since then, and still, several ethnobotanists have come and sought new perspectives regarding medicinal plants in Colombia. The studies are commonly related to quantitative species richness in wild, indigenous and rural communities or commonly visited marketplaces (Frausin et al. 2010; Vásquez et al. 2015; Lima et al. 2016; Pérez & Matiz-Guerra 2017; Bussmann et al. 2018a; Rosero-Toro et al. 2018; Polindara Moncayo & Sanabria Diago 2022). Nevertheless, individual studies about ethnobotanical knowledge (Agudelo-Hurtado 2020) and supply value chain (Pérez & Raz 2022) concerning medicinal species in Colombia can be found.

Although researchers have many challenges and gaps to overcome, little is known about the plant trade and its relationship with vendors. Therefore, this study aims to explore Colombia's plant heritage and economic relationships, particularly with medicinal plants.

3. Aims of the thesis

This thesis aims to document and understand the ethnobotanical and socioeconomic knowledge by performing a comprehensive rapid rural appraisal of the medicinal plant trade within markets of five different cities in the Colombian Andes.

The thesis is divided into three main parts. The first part documented and evaluated the diversity and origin of the most sold-out medicinal plant species at the markets to create a baseline of the most commercialised species in the region. The second part extended the previous one through the in-depth evaluation of three local species regarding to their importance, use and rentability. The last part documented vendors' knowledge and their socioeconomic background to gain more perspective on which factors play a crucial role in the Colombian medicinal plant trade, including the obstacles they had to overcome as influence of Covid 19.

Altogether this research seeks to find an understanding of the medicinal trade in the Colombian Andes and provide insights to contribute to current and enhance future research in this area.

4. Methodology

4.1. Study sites characteristics

The study was conducted in five Andean region cities according to their population density, location in the mountain range and altitude. Only cities above 350,000 inhabitants were selected to prevent the unavailability of the market on business days. Moreover, cities were arranged in separate mountain areas divided into five parts: Cauca River valley between the western and central mountain range; Central Mountain range; Pasto Massif, which connects the Central and East Mountain range; Magdalena River valley; East Mountain range. The cities were chosen to represent the different altitudinal zones of the Cordillera. As a result, the individual sites covered a gradient from 400 to 2,500 m asl. The average difference between sites was 500 m asl. By separating the ranges and altitude diversity of ecological zones was ensured. The resultant cities which are seen in Figure 2. were Neiva (2.931949, -75.283846; 442m asl), Bucaramanga (7.120054, -73.120446; 959m asl.), Medellín (6.248422, -75.569546; 1,495m asl.), Manizales (5.062851, -75.500701; 2,160m asl.) and San Juan de Pasto (1.214969, -77.277681; 2,527m asl.).

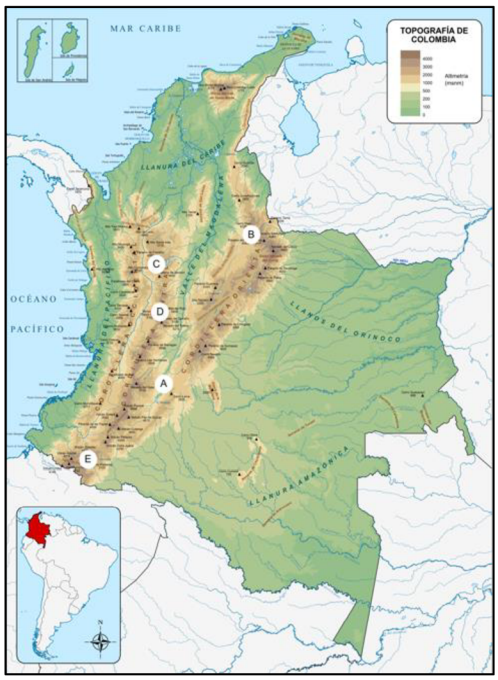


Figure 3. Distribution of five selected cities.

(A) Neiva, (B) Bucaramanga, (C) Medellín, (D) Manizales, (E) San Juan de Pasto

In each city one to two major markets were visited (Table 1). The markets were selected according to their availability, size, the popularity of medicinal plants sold and safety.

Table 1. Selected local markets divided by cities.

Cities	Markets
Pasto	Plaza de Mercado El Potrerillo
	Mercado los dos Puentes
Medellín	Placita de Flórez
	Plaza de la América
Bucaramanga	Plaza de Guarín
	Mercado de San Francisco
Neiva	Plaza Cívica
Manizales	Centro galerías plaza de mercado

Medicinal plant markets were part of larger market units also selling fruits, vegetables, animals, electronics, clothes, and other household supplies. In the case of Pasto, Medellín, Bucaramanga and Manizales the medicinal plants were solely sold in individual pavilions, or specific areas (levels or aisles) within the market, each vendor had a booth or stall, visibly divided from the others by the wall (Figure 4). Another form was as an outdoor market as in Neiva, where stalls were standing outside on small movable booths on the streets, usually under a tent or different artificial types of roofs. In

Figure 4. An example of stall types

(A) Indoor stall in San Francisco market, Bucaramanga; (B) Outdoor stall in Plaza Cívica,

both types, mostly fresh plants were sold; the rest were dry, packed or processed into oils, extracts, and different types of ointments (Figure 5).

Figure 5. Types of the plant sold in Plaza Cívica, Neiva

(A) Fresh plants, oilments and extracts (B) Dry plants

4.2. Data collection

The data were collected from August to the end of September 2022, a total of 30 vendors. The herbalists were 93% of local origin, between 27 and 78 years old, with the highest age representation from 51 to 60. The oldest respondent was 78 years old. Of the vendors interviewed, more than 50% were females, but the overall gender difference was insignificant.

The education level was estimated through years of schooling valid in Colombia, considering that five years of education means primary school and eleven years signifies secondary school. Higher education, seen in Table 2, consisted of college education (13 years of schooling), and university (16 years of schooling). Only one vendor had a university education; he simultaneously fell into the youngest category of herbalists. A similar situation occurred in Neiva, where the highest mean value of education was 11 years (college). At the same time, it is the city with the lowest average age value, where respondents ranged from 25 to 43 years old.

Most vendors from first and second socio-economic classes lived in a household of 3 to 4 people (83%). "Estrato económico" or socio-economic class, depends on the

family's conditions and the environment or area in which their home is located. Through socio-economic class are made household charges as public services or taxes, which give higher fees to higher "estrato". It is not possible to define a household income by "Estrato económico" but it is likely that people with lower "Estrato" will reach a lower pay grade; thus, the lower fees have a higher significance for them (Cogollo Jiménez 2012). From the questionnaire, only one respondent belonged to higher "estrato". The estrato ranges from 0 to 6, where 0 represents the lowest (poorest) and 6 the highest (richest).

Table 2. Socio-demographic profile of respondents

Parameter	Specification	Freq.	Percentage
Gender	Male	12	40%
	Female	17	57%
Age	<35	0	30%
	36-50	8	27%
	>50	0	43%
Education	None	4	13%
	Primary school	13	43%
	High School	10	33%
	Higher education*	3	10%
Marital status	Single	10	33%
	Partnership	20	67%
Household size	1-2	7	23%
	3-4	16	53%
	5-6	5	17%
	>6	2	7%
Socioeconomic status	1	18	60%
	2	7	23%
	3	4	13%
	5	1	33%

*College and university
Freq.=number of vendors in the same category
Note: The socio-economic status corresponds to the area where the household is located. A lower "socio-economic status" number allows paying lower deposits for services and taxes.

The vendors were selected through convenient method as their availability, willingness to share information and snow-ball method (Ceuterick et al. 2008; Navia et al. 2021) when each vendor recommended the following one. They were asked questions in the form of semi-structured to structured interviews with use of freelisting (Corroto & Macía 2021; Benkhaira et al. 2021; Dutta et al. 2022) prepared before arriving at the final destination. The questionaire was modified after the first experiences in the local market to secure its comprehensibility and to guarantee the gathering most essential data. There were two interviewers. One was a native speaker discussing the topics verbally with the vendor in Spanish language and the second one to record the answers and ensuring the collection of entirely clear data (Figure 6).

The questionary was composed of three main parts: (i) Listing ten most sold plants, (ii) Ethnobotanical information about three selected species, (iii) Vendor's professional and economic background together with financial obstacles encountered over the years.

Figure 6. Data collection in Plaza de Mercado El Potrerillo, Pasto

4.2.1. Most commercialised species

The first part intended to ask and collect the information about their top ten most sold species. The plant material was identified thanks to earlier research, including the recognition of the Colombian equivalent to the Latin name with the help of published literature, specifically a study carried out by Bussmann et al. (2018), who listed all Latin and local names in their study. The species that have not been identified on the market

were bought and taken pictures of for further identification by the local plant guidebook. The most commercialised species not only depict the market trend in terms of commercialisation, but also traces the demand needs which could eventually display the health issues that the buyers intend to address by acquiring these species (Pawera et al. 2016; Navia et al. 2021).

4.2.2. Ethnobotanical evaluation of three preselected species

Furthermore, the second part was established on prior research of medicinal plants native for Colombian Andes. Three medicinal species were selected to ask about their ethnobotanical information as their local name, part used, dosage, administration, quantity sold among other relevant data.

The species were selected based on their availability in the local markets, and the claim was confirmed mainly by study of Bussman et al. (2018) in Bogotá market research. At the same time, two species were listed among the 20 species of high importance in the same study. Another criteria was for them to be associated with major health issues affecting the Colombian population as diabetes, heart diseases connected to high cholesterol levels and kidney diseases. The elected species were *Equisetum bogotense* Kunth, *Myrcianthes leucoxyla* (Ortega) McVaugh and *Juglans neotropica* Diels, supported by number of different studies (Gutiérrez & Guarín 2007; Santamaría 2010; Giraldo Quintero et al. 2015; Vanegas & Roldan Rojas 2018; Maldonado & Rodríguez Calderón 2019; Hernández Moreno et al. 2021; Ortiz et al. 2022).

Equisetum bogotense Kunth

Colloquially known as Horsetail, it is one of the oldest plants diversified in the early Jurassic era, which thanks to the found fossils, could be said that are one of the basal fern families (Kessler & Smith 2017; Christenhusz et al. 2021).

The Andean horsetail or *Equisetum bogotense* Kunth., belonging to the family Equisetace, originates in Andean region, where it is commonly called "Cola de Caballo", Spanish translation for horsetail. It is an erect perennial herb with an epiphytic shrub-like habitus which grows in moist places in higher mountain ranges, mainly above 2,000 m asl. It can grow wild near the shores of lakes, riverbanks, or streams simultaneously along the roads leading throughout Central and South America (Kessler & Smith 2017;

Paniagua-Zambrana et al. 2020). Horsetail grows up to 50 cm and, like other horsetails from its family, has a green photosynthetic jointed stem, 2 mm wide with separate segments from which grow lateral branches with four ridges irregularly and reproduces by spores on stalked strobili (Kessler & Smith 2017; Paniagua-Zambrana et al. 2020; Boeing et al. 2021).

Throughout time, the plant gained importance in traditional human medicine, which uses it for its valuable and diverse purposes (Rodriguez et al. 1994) which are given by its main biologically active substances as pyridine alkaloids, nicotine and palustrine (equisetin), glycosylated flavonoids, steroids, triterpenes, saponins, silicic acid, phenolic compounds, tannins and leucoanthocyanins (Pinzón 2008).

E. bogotense is originally described as having analgesic effects on the stomach, foot and bone issues as fractures and sprains; it is used to treat childhood infections or for postpartum washing due to its anti-inflammatory effects. The root is attributed to astringent, diuretic, emollient, stomachic and haemostatic properties. Externally, infusions and decoctions are used to wash wounds and sores. The decoction of the stem and fresh leaves or the powder macerated in wine is used orally to treat gastrointestinal and genitourinary disorders (Pinzón 2008; Paniagua-Zambrana et al. 2020; Boeing et al. 2021). Bussmann et al. (2018) also noted other medicinal uses, such as the effect on metabolism, digestive system, blood and circulatory system, dental health, respiratory system, sexual health and impact on skin tissue or use as an antipyretic. Among all purposes, this specie and its family are widely known to be used in treatment of urinary system applications, cystitis, prostate problems, diuretic, kidney, and infections as many studies suggest (Rodriguez et al. 1994; Lemus et al. 1996; Wright et al. 2007; Bussmann et al. 2015, 2018a; Paniagua-Zambrana et al. 2020; Boeing et al. 2021). As abovementioned *E. bogotense* can be prepared for use in various forms as powder of the dehydrated plant to reconstitute, infusion, decoction or as tincture at a 1:8 plant water ratio (Pinzón 2008).

Andean horsetail did not demonstrate any toxicity effect on humans when administrated orally, even in higher dosages up to 1-5 kg. Misleading confusion with *Ephedra americana* Humb. & Bonpl. ex Willd. reported in Bolivian markets (Bussmann et al. 2015) which could cause abortions, insomnia, irritation, nausea, tachycardia, headaches, or potential addiction.

Myrcianthes leucoxyla (Ortega) McVaugh

Arrayán or *Myrcianthes leucoxyla* is native to northern South America as Ecuador, Venezuela and Colombia. The English equivalent is Castile guava, but in Colombia, it carries many other names as arrayán de clima frío (cold climate myrtle), arrayán grande (big myrtle) or arrayán blanco (white myrtle), which point out its natural occurrence or its morphological appearance. It is found in the humid Andean forests or savannas, searching shadow or half-sunny positions on the bottom of slopes and ravines (Cardozo Gutiérrez et al. 2011; Colmenares-Trejos et al. 2011; Granados et al. 2014).

Arrayán is an evergreen shrub or tree reaching up to 6 m of height occurring in higher elevations from 2,100 to 3,000 m asl. The tree has brownish to radish bark and a dense crown with often singular and knotty branches (Colmenares-Trejos et al. 2011; Quijano-Célis et al. 2016). As a member of the family, Myrthaceae is characterised by lanceolate, leathery, ovate and entire leaves 3-5 cm long and up to 3 cm wide (Cardozo Gutiérrez et al. 2011; Novák & Skalický 2017). The flowers are organised by three on a stalk or solitary 1 cm in diameter. Its fruits are small fleshy drupes reaching 25 mm in diameter. They are of cream yellow to dark purple colour when ripped, carrying one seed in a single fruit.

Castile guava is known for its aromatic essential oils, which are present in its leave tissues. A Quijano-Célis (2016) study revealed high diversity among biochemical components. The major essential oil families were: monoterpene hydrocarbons, oxygenated sesquiterpenes, oxygenated monoterpenes, sesquiterpene hydrocarbons, and the major constituents were limonene, myrcene and spathulenol (Quijano-Célis et al. 2016). Based on its diverse chemical composition, this plant possesses multiple therapeutical uses. Locally are, the plants' leaves being antioxidant and analgetic for stomach aches, headaches, or toothaches. It helps against diarrhoea, and it is used to calm nerves. The tree bark is used for diabetes, hypertension, or to lower cholesterol levels (Granados et al. 2014; Ospina et al. 2016; Bussmann et al. 2018a).

Aside from its pharmaceutical utilisation Arrayán serves for the Andean ecosystem restoration project as a fast-growing tree to prevent soil erosion and is also used as an ornamental shrub or tree (Cardozo Gutiérrez et al. 2011; Quijano-Célis et al. 2016).

Juglans neotropica Diels

Andean Walnut (*Juglans neotropica*), locally called Nogal, Cedro negro, Cedro or Nogal bogotano, is a deciduous tree originating in South American Andes (Valencia 1995; Mostacero León et al. 2017; Vanegas & Roldan Rojas 2018; Bussmann et al. 2018a).

It is a slow-growing tree which can reach up to 48 meters when mature, and its black trunk with cracked bark spreads up to 60 cm in diameter. The crown is irregularly rounded and dense, which lowers the number of plants growing below them and its need for competition. Nogal has thick, oval, alternate, composite leaves of 7-19 light green colour leaflets. The leaves are with glandular-hairy veins and roughly sawn edges. When leaves are broken, they are distinguished for their strong smell. The inflorescences are spike-like catkins emerging from the leaf axils; the male spikes are long, lateral, and solitary, with white flowers supported by an ellipsoid receptacle containing an elongated bract. The female spikes are short, terminal and come out in pairs, with 2 to 25 pale yellow flowers. The fruits are drupes, nearly rounded, dark brown to black, with a thick shell. It is a monoecious specie reproduced annually by cross-pollination (Nieto & Rodríguez 2002; Vanegas & Roldan Rojas 2018; Ramírez & Kallarackal 2021; TTF 2022; FPI 2023).

Latin name, *Juglans neotropica*, characterises the ecosystem the tree lives. It is found on moist soils along streams and riverbanks in Neotropical montane forests or as a field boundary. It grows on sunny positions from 1,800 to 3,500 m asl. Rainfall is low to medium, and preferred temperatures are between 14 to 22 °C (Wright et al. 2007; Vanegas & Roldan Rojas 2018; Medina et al. 2021; TTF 2022).

Within its structure, Nogal holds several health and environmentally beneficial properties. From roots to seeds, it contains juglandins, juglone, gallic acid, catechine and a wide range of unsaturated fatty acids like guglandic and lipids such as Omega 3 and 6, folic, linoleic, oleic, palmitic, α-linoleic, elaidic, stearic, lauric, myristic, phenolic and flavonoids. The tree holds many bioactive compounds influencing the human immune system and health overall, among others, quinones, alkaloids, minerals (Fe, K, P, Ca), vitamins (B, C, E) together with lipids and proteins (globulins, albumins, glutelins and prolamins) (Vanegas & Roldan Rojas 2018; Vilcacundo et al. 2018).

Thanks to these properties, the Andean walnut is used to cure and prevent various health dysfunctions, and as well as blood cleansing, to prevent constipation, indigestions, liver problems, and diabetes; it also used against urinary infections or mouth ulcers and has analgetic, antifungal, antiseptic and antioxidant effects (Lopez et al. 2001; Hurtado Manrique et al. 2015; Vilcacundo et al. 2018; Bussmann et al. 2018a). In the study of Bussmann et al. (2018), Nogal, in addition to those already mentioned, was reported as used for alopecia, against dandruff, astringent, promoting sweating, healthy hair, dysmenorrhea, vaginal discharge or skin tonic.

Walnuts as a genus *Juglans* compound one of the commercially important nut trees, like *Juglans nigra* and *Juglans regia*, the most cultivated species overall (Stanford et al. 2000; Ramírez & Kallarackal 2021). This genus also holds together excellent quality timber, and it is another purpose for their high cultivation. In the case of *Juglans neotropica*, timber logging to obtain wood for furniture, musical instruments or interior carpentry is a reason for the excessive loss of individuals within its natural occurrence (Vanegas & Roldan Rojas 2018; Ramírez & Kallarackal 2021). International Union for Conservation of Nature and Natural Resources (IUCN), by the year 1998, had added the Andean walnut to The IUCN Red List of Threatened Species in the Andean region of South America (IUCN 1998). Nowadays, higher-mentioned regions try to implement Nogal back into their natural area and somewhat prevent the specie disappearance practices by using it to recover soils degraded by mining, cattle ranching or other types of erosion, as well as for the enrichment of secondary forests. Furthermore, for its carbon sequestering properties is also used as an ornamental specie in the cities (Mostacero León et al. 2017; Vanegas & Roldan Rojas 2018; Ramírez & Kallarackal 2021).

4.2.3. Socio-economic background of medicinal plant trade

Finally, the last segment of the interview aimed to describe how profitable are the selected three species in mater of price. The questions included details about its collection, transportation to the vendor and costs connected to the rentability of the product. Another part was dedicated to describe vendors' background, experience and education, what led them to this occupation (Navia et al. 2021; Chaachouay et al. 2022). Among others, they were asked about their personal experience connected to changes in the market throughout the years and how the pandemic influenced their trade (Gereffi 2020; Van

Hoyweghen et al. 2021). Special regard was taken on the prices connected to individual matters leading to the delivery of the goods to the hands of the seller. This part was established on a Likert scale grading from one to five when "one" corresponded to the biggest change and "five" to the lowest.

4.3. Data analysis

After the data were collected, they were entered into an Excel spreadsheet, cleared, coded, and sorted by questionnaire sections, cities, and vendors to facilitate its manipulation. Most data were analysed using basic descriptive statistics and presented as tables and graphs. The analysis of ethnobotanical data was calculated by Preference ranking, Use Value (UV), Informant Consensus Factor (ICF) and Informant Agreement Ratio (IAR).

Most commercialised species

In order to determine the most sold and preferred species, ranking analysis was used. The species were categorised by subjective selling importance according to the vendors, where the most important was 1 had the lowest value, and 10 was the biggest value (Lulekal et al. 2008; Ashagre et al. 2016; Behailu & Temesgen 2017).

Ethnobotanical evaluation of three selected species

To estimate relative importance of the three selected species, Use Value was used by using the citation frequency. It is calculated by the number of citations U which corresponds to the number of informants who mentioned a particular plant in their top list, divided by the total respondents N. The species with higher frequency obtain higher UV (Pawera et al. 2016; Assefa et al. 2020; Chaachouay et al. 2022).

$$\mathrm{UV} = \frac{\mathrm{U}}{\mathrm{N}}$$

Informant Consensus factor (ICF) displays homogeneity among the respondents about particular uses of plant species. The low value of ICF (0) suggests a lack of consensus among informants, whereas the higher the value, there is also more agreement among respondents. It was calculated by a formula where Nur is the number of citations for every use category, and Nt is the sum of cited species used for a specific category (Pawera et al. 2016).

$$\mathrm{ICF} = \frac{\mathrm{Nur} - \mathrm{Nt}}{\mathrm{Nur} - 1}$$

Informant Agreement Ratio (IAR) displays the level of agreement within the separate species within the usage categories. To evaluate the IAR, Use Report (UR) value was used, which represents to the sum of all responders using a species for the same use category. IAR corresponds to sum of all respodents using species for the same application category. The resultant value also varies from 0 to 1; when the agreement is more significant, the value is closer to 1. On the contrary, if the number of categories equals the number of citations, the value is 0. It is calculated by an equation where Nr is the number of citations, and Na corresponds to the number of usage categories (Dutta et al. 2022; Chaachouay et al. 2022).

$$\mathrm{IAR} = \frac{\mathrm{Nr} - \mathrm{Na}}{\mathrm{Nr} - 1}$$

5. Results

5.1. Most commercialised species

The total amount of 295 responses were collected from the most popular plants sold on the visited markets, among which 55 medicinal species were recognised (Table 3). Four plants were not recognised by botanical name. The species belonged to 30 families, with the highest representation of the family Lamiaceae (16%), Asteraceae (13%), Apiaceae (7%) and Acanthaceae (5%), as shown in Figure 7. The majority of the species were herbs accounting for 78%, and the rest were trees (13%) and shrubs (9%). The plants were sold in various forms, with aerial parts being the most popular (66%), followed by leaves (23%), bark (7%) and root (4%).

Only 16 species (29%) of the most sold originated in Tropical America the rest 71% of the most sold species were introduced, mainly from the Mediterranean region and the Middle East (27%), and Europe (16%), seen in the Figure 8. The origin in Colombian Andean region had five species: *Equisetum bogotense* Kunth, *Salvia scutellarioides* Kunth, *Trichanthera gigantea* (Bonpl.) Nees, *Myrcianthes leucoxyla* (Ortega) McVaugh and *Juglans neotropica* Diels.

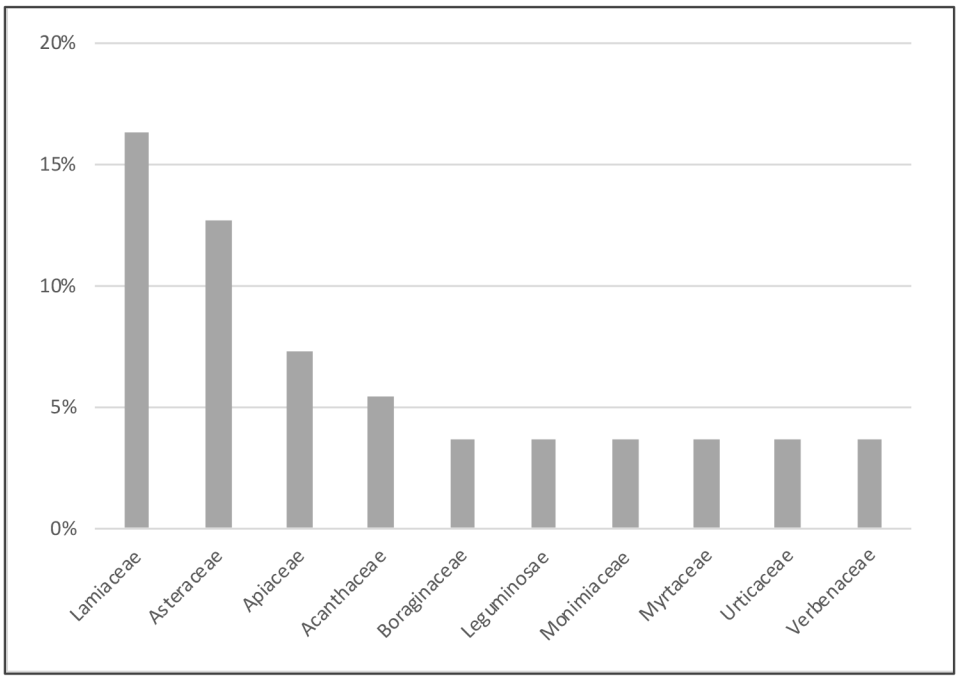


Figure 7. Dominant plant families

Table 3. List of the most sold medicinal plant species

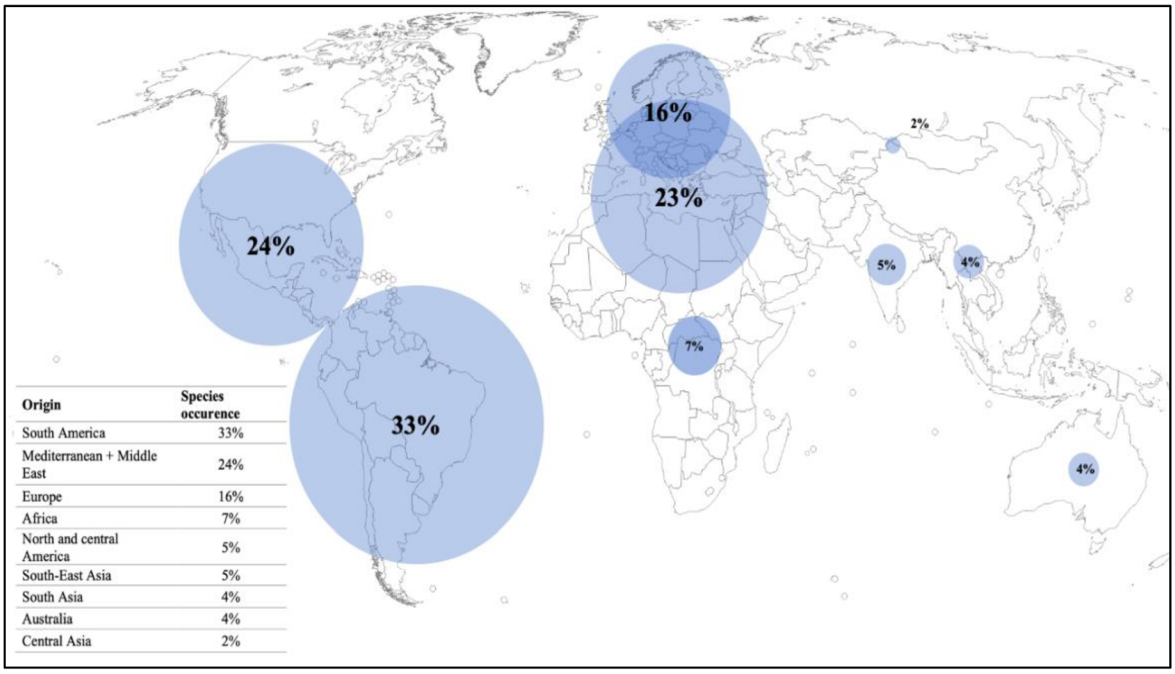
Botanical name	Local name	Family	Habitat	Part sold	Origin	Citation number	Rank
***Achyrocline bogotensis* (Kunth) DC.**	Vira vira	Asteraceae	herb	aerial parts	Americas	7%	18
***Alcea rosea* L.**	Malvarosa	Malvaceae	herb	aerial parts	Europe	7%	17
***Aloysia citriodora* Paláu**	Cidrón	Verbenaceae	shrub	leaves	Americas	19%	10
***Ambrosia peruviana* Willd.**	Altamisa	Asteraceae	herb	aerial parts	Americas	3%	24
***Anethum graveolens* L.**	Eneldo	Apiaceae	herb	aerial parts	South-East Asia	2%	33
***Anredera cordifolia* (Ten.) Steenis**	Insulina	Basellaceae	herb	leaves	Americas	3%	25
***Borago officinalis* L.**	Borraja	Boraginaceae	herb	aerial parts	Mediterranean + Middle East	2%	29
***Calendula officinalis* L.**	Caléndula	Asteraceae	herb	aerial parts	Mediterranean + Middle East	42%	1
***Cinnamomum verum* L.**	Canela	Lauraceae	tree	bark	South Asia	2%	22
***Cordia alliodora* (Ruiz & Pav.) Oken**	Laurel	Boraginaceae	tree	leaves	Americas	5%	20
***Curatella americana* L.**	Chaparro rojo	Dilleniaceae	tree	bark	Americas	5%	22
***Cymbopogon citratus* (DC.) Stapf**	Limoncillo	Poaceae	grass	leaves	South Asia	15%	16
***Cynara cardunculus* L.**	Alcachofa	Asteraceae	herb	aerial parts	Africa	2%	30
***Drymonia serrulata* (Jacq.) Mart.**	Destrancadera	Gesneriaceae	herb	aerial parts	Americas	2%	35
***Dysphania ambrosioides* (L.) Mosyakin & Clemants**	Paico	Amaranthaceae	herb	aerial parts	Americas	3%	31
***Equisetum bogotense* Kunth ***	Cola de caballo	Equisetaceae	herb	aerial parts	Americas	10%	14

Botanical name	Local name	Family	Habitat	Part sold	Origin	Citation number	Rank
***Eucalyptus globulus* Labill.**	Eucalipto	Myrtaceae	herb	aerial parts	Australia + Pacific	19%	8
***Foeniculum vulgare* Mill.**	Hinojo	Apiaceae	herb	aerial parts	Europe	7%	31
***Fumaria officinalis* L.**	Sangre Cristo	Papaveraceae	herb	aerial parts	Mediterranean + Middle East	3%	20
***Hibiscus sabdariffa* L.**	Flór de Jamaica	Malvaceae	shrub	leaves	Africa	5%	13
***Juglans neotropica* Diels. ***	Nogal	Juglandaceae	tree	leaves, bark	Americas	7%	31
***Justicia pectoralis* Jacq.**	Amansatoros	Acanthaceae	herb	aerial parts	Americas	3%	23
***Justicia secunda* Vahl**	Chingamochila	Acanthaceae	herb	aerial parts	Americas	3%	33
***Matricaria chamomilla* L.**	Manzanilla	Asteraceae	herb	aerial parts	Europe	34%	2
***Medicago sativa* L.**	Alfalfa	Leguminosae	herb	aerial parts	Mediterranean + Middle East	3%	21
***Melissa officinalis* L.**	Toronjil	Lamiaceae	herb	aerial parts	Mediterranean + Middle East	10%	17
***Mentha spicata* L.**	Hierbabuena	Lamiaceae	herb	aerial parts	Mediterranean + Middle East	37%	3
***Mentha x piperita* L.**	Menta	Lamiaceae	herb	aerial parts	Mediterranean + Middle East	37%	4
***Moringa oleifera* Lam.**	Moringa	Moringaceae	tree	leaves	South Asia	12%	9
***Myrcianthes leucoxyla* (Ortega) McVaugh ***	Arrayán	Myrtaceae	shrub	bark	Americas	5%	28
***Nicotiana tabacum* L.**	Tabaco	Solanaceae	herb	leaves	Americas	2%	30
***Ocimum americanum* L.**	Albahaca	Lamiaceae	herb	aerial parts	Mediterranean + Middle East	25%	6

Botanical name	Local name	Family	Habitat	Part sold	Origin	Citation number	Rank
***Origanum vulgare* L.**	Oregano	Lamiaceae	herb	aerial parts	Mediterranean + Middle East	10%	17
***Parietaria debilis* G. Forst.**	Palitaria	Urticaceae	herb	aerial parts	Australia + Pacific	2%	34
***Petiveria alliacea* L.**	Anamú	Phytolaccaceae	herb	aerial parts	Americas	22%	7
***Petroselinum crispum* (Mill.) Nyman ex A.W. Hill**	Perejíl	Apiaceae	herb	aerial parts	Mediterranean + Middle East	2%	27
***Peumus boldus* Molina**	Boldo	Monimiaceae	shrub	leaves	Americas	2%	30
***Pimpinella anisum* L.**	Anís	Apiaceae	herb	aerial parts	Mediterranean + Middle East	2%	31
***Pinus patula* Schltdl. & Cham.**	Pino	Pinaceae	tree	leaves	Americas	2%	27
***Piper obtusilimbum* C. DC.**	Desvanecedora	Piperaceae	tree	leaves	Americas	3%	31
***Rhodiola rosea* L.**	Artica	Crassulaceae	herb	root	Europe	2%	31
***Rosmarinus officinalis* L.**	Romero	Lamiaceae	herb	aerial parts	Mediterranean + Middle East	15%	12
***Ruta graveolens* L.**	Ruda	Rutaceae	herb	leaves	Europe	31%	5
***Salvia scutellarioides* Kunth ***	Salvia	Lamiaceae	herb	aerial parts	Americas	8%	15
***Satureja brownei* (Sw.) Briq.**	Poleo	Lamiaceae	herb	aerial parts	Africa	7%	19
***Senna alexandrina* Mill.**	Sen	Leguminosae	herb	aerial parts	Africa	2%	31
***Spilanthes oppositifolia* (Lam.) D'Arcy**	Botón de oro	Asteraceae	herb	aerial parts	Americas	2%	31
***Taraxacum officinale* F.H. Wigg.**	Diente león	Asteraceae	herb	aerial parts	Central Asia	2%	33
***Thymus vulgaris* L.**	Tomillo	Lamiaceae	herb	aerial parts	Mediterranean + Middle East	10%	11

Botanical name	Local name	Family	Habitat	Part sold	Origin	Citation number	Rank
***Trichanthera gigantea* (Bonpl.) Nees ***	Cuchiyuyo	Acanthaceae	shrub	leaves	Americas	2%	35
***Urtica urens* L.**	Ortiga (Pringamosa)	Urticaceae	herb	aerial parts	Europe	10%	17
***Valeriana officinalis* L.**	Valeriana	Caprifoliaceae	herb	aerial parts	Europe	8%	16
***Verbena officinalis* L.**	Verbena	Verbenaceae	herb	aerial parts	Europe	2%	34
***Viola odorata* L.**	Violeta	Violaceae	herb	aerial parts	Europe	2%	35
***Zingiber officinale* Roscoe**	Jengibre	Zingiberaceae	herb	root	South-east Asia	3%	26
Not found	Acacia	Not found	Not found	Not found	Not found	2%	32
Not found	Descansés	Not found	Not found	Not found	Not found	2%	35
Not found	Mambipaqué	Not found	Not found	Not found	Not found	2%	26
Not found	Mejerava	Not found	Not found	Not found	Not found	2%	23

*Species native to Colombian Andes



Origin	Species occurence
South America	33%
Mediterranean + Middle East	24%
Europe	16%
Africa	7%
North and central America	5%
South-East Asia	5%
South Asia	4%
Australia	4%
Central Asia	2%

Figure 8. Native range of preferred species

The identified 55 species were lined up according to their number of citations. Only seven displayed a higher percentage than 20%; among them were *Calendula officinalis* L. (25%), *Mentha spicata* L. (37%), *Mentha* x *piperita* L. (37%), *Matricaria chamomilla* L. (34%) *Ruta graveolens* L. (31%), *Ocimum americanum* L. (25%) and *Petiveria alliacea* L. (22%).

The number of citations highly corresponded to preference ranking. It was found that 90% of the top ten most preferred species were identical. The only difference was in *Cymbopogon citratus* (DC.), cited among the ten most frequently mentioned plants but did not score as high by preference ranking. The first specie with 186 ranking points was *Calendula officinalis* L. This plant was the most preferred one among the local customers and defined as the most popular choice in Pasto, Medellín and Manizales and simultaneously had the highest amount in the first position, followed by *Matricaria chamomilla* L. On the contrary, *Viola odorata* L. *Drymonia serrulata* (Jacq.) Mart., *Trichanthera gigantea* (Bonpl.) Nees, were the least preferred from the list.

5.2. Ethnobotanical evaluation of three preselected species

More than 90% of the interviewed vendors stated to commerce the preselected species: *Equisetum bogotense* Kunth, *Myrcianthes leucoxyla* (Ortega) McVaugh and *Juglans neotropica* Diels (Figue 9).

Figure 9. Three investigated species in their most sold-out form form

(A) *Equisetum bogotense* Kunth; (B) *Myrcianthes leucoxyla* (Ortega) McVaugh; (C) *Juglans neotropica* Diels.

During their ethnobotanical evaluation, data were collected describing their use, form and shape for sale, and plant collecting habits (Table 4). Only *Equisetum bogotense* was sold in one form (the whole plant), with the lowest lastability an average of 3.4 days. For the administration the most prevailing was oral, followed by bath and washing. The dosage in all tree species varied enormously. All species agreed that majority is collected from the wild, with the highest representation of Andean horsetail (71%).

Other collected data demonstrated plant usage in specific categories. From the total number of responses 168 were comprised 13 usage categories, of which 11 were to treat diseases or illness symptoms (Table 5). In a separate specie evaluation, the Horsetail was sold mainly for the urinary system and its disorders. The non-specific symptoms connected with hair maintenance was by the number of responses marked as the second most frequent in the case *of Equisetum bogotense*.

Table 4. Description of selected species.

	Plant part		Product form		Durability if fresh	Administration		Dosage		Plants state	
Equisetum bogotense Kunth	Entire plant	100%	Fresh	55%	1-9 days	Oral	69%	Whole plant [g/l]	15-65	Wild	71%
						Bath	19%				
						Washing	7%				
			Dry	45%		Rubbing	2%			Cultivated	29%
						Compress	2%				
Juglans neotropica Diels.	Leaf	59%	Fresh	47%	1-8 days	Oral	74%	Branch [g/l]	2-22.5	Wild	64%
	Branch	18%				Bath	24%				
	Seed	13%	Dry	53%		Washing	3%			Cultivated	36%
	Bark	10%									
Myrcianthes leucoxyla (Ortega) McVaugh	Bark	47%	Fresh	66%	3-15 days	Oral	53%	Leaves [g/l]	3-75	Wild	65%
	Leaf	39%	Dry	34%		Washing	8%	Bark [g/l]	10-60	Cultivated	35%
	Branch	14%				Bath	8%	Bark [cm/l]	4-20		

Table 5. Usage categories and descriptions

Category	Local usages and diseases recognised by vendors
Blood and circulatory system	Hypertension
Digestive system	Diarrhoea, livers
Endocrine system	Diabetes
General illnesses	Haemorrhoids, bacterial infections, yellow fever, fever, allergies
Metabolism and nutrition	Lowering cholesterol
Nervous system	Memory loss, vertigo
Reproductive system and sexual health	Vaginal infections, menopause, prostate
Respiratory system	Respiratory diseases
Skeleto-muscular system	Bone strength, arthritis, gout, leg, pain, pregnancy pains, teeth pain
Skin and subcutaneous tissue	Inflammation
Urinary system	Urinary infections, kidney-stones, kidneys, hydronation
Non-specific symptoms	Hair lightener and stronger, hair growth, weight loss
Food	Food

More than 40% of responds recognised *Juglans neotropica* together with *Myrcianthes leucoxyla* for threating symptoms of diabetes and marked as the second most important lowering cholesterol levels.

The ICF value seen in Table 6 depicts informants' agreement on specific usage. The factor varied from 0 to 1 with average value 0.7. The highest value was calculated for food category (ICF=1), endocrine system (ICF=0.98) and urinary system (ICF=0.97). The endocrine system was simultaneously the most frequently cited (Nur=43). On the other hand, a high level of disagreement was found with no consensus (ICF=0) within respondents for nervous system with skin and subcutaneous tissue.

A consensus on the use of individual medicinal species for the treatment of various disorders and other cultural or aliment usage in a given category was assumed by the IAR (Table 7). All tree species recorded a high IAR value, which ranged from 0.76 to 0.89, with the highest agreement on *Equisetum bogotense*.

Table 6. Use categories organised according to the descending order of the ICF.

Use category	Nt	Nur	ICF	% UR
Food	1	4	1.00	1.223
Endocrine system	2	43	0.98	13.150
Urinary system	2	37	0.97	11.315
Non-specific symptoms	3	22	0.90	6.728
Metabolism and nutrition	2	10	0.89	3.058
Digestive system	2	9	0.88	2.752
Reproductive system and sexual health	2	7	0.83	2.141
Blood and circulatory system	2	6	0.80	1.835
Skeleto-muscular system	3	11	0.80	3.364
General illnesses	3	9	0.75	2.752
Respiratory system	3	5	0.50	1.529
Nervous system	2	2	0.00	0.612
Skin and subcutaneous tissue	3	3	0.00	0.917

Nur = number of citations for every use category; Nt = the sum of cited species used for a specific category; %UR = % of responders using a species for the same use category

Table 7. Traditional uses of medicinal plants among herbal vendors.

Plant specie	Reported uses	UR	Na	UV	IAR
Equisetum bogotense Kunth	Digestive system, General illnesses, Nervous system, Reproductive system and sexual health , Respiratory system, Skeleto-muscular system, Skin and subcutaneous tissue, Urinary system*, Non-specific symptoms	72	8	2.40	0.90
Juglans neotropica Diels.	Blood and circulatory system, Endocrine system*, General illnesses, Metabolism and nutrition, Nervous system, Reproductive system and sexual health, Respiratory system, Skeleto-muscular system, Skin and subcutaneous tissue, Non-specific symptoms	53	10	1.77	0.83
Myrcianthes leucoxyla (Ortega) McVaugh	Blood and circulatory system, Digestive system, Endocrine system*, General illnesses, Metabolism and nutrition, Respiratory system, Skeleto-muscular system, Skin and subcutaneous tissue, Urinary system, Non-specific symptoms, Food	43	11	1.43	0.76

*category represented with the highest number of citations

Na = number of usage categories

5.3. Socio-economical background of selling

5.3.1. Economical importance of three preselected species

The three selected plants *Equisetum bogotense* Kunth, *Myrcianthes leucoxyla* (Ortega) McVaugh and *Juglans neotropica* Diels, were also examined for their economic role in local markets. It was found that over 90% of these species were not harvested by vendors but by collectors. 88% of the plants were collected near the city where the market was located and then later transported by a shared car along with the other species. The exception of the origin of the herbs was, for the most part, at Neiva, with 39% of herbalists indicating a collection of plants from the Bogotá district. In the case of *E. bogotense*, the product was delivered in frequency from every day of the week to once a month, with the mean value among all markets reaching 1-2 times per week. *J. neotropica* was delivered mainly once a week, and *M. leucoxyla* was the least frequently received by sellers.

Vendors also determined how they perceive the demand on the market concerning the trade of these three species. In the case of *E. bogotense* recorded 96% of the same or higher commerce. Their justifications for the increases included reasons concerning the pandemic and Covid-19, when interest in medicinal plants has increased. Another common reasoning concluded that the plant has properties beneficial for common health problems in the community. Only one herbalist answered negatively and justified it with the increase in the price of medicinal plants. For *J. neotropica*, the results were less favourable. 61% of respondents did not precive any change in demand, while 23% reported a decline. The loss of demand was often justified by the marketing rise of other plant species with similar effects or by environmental concerns related to the protection of the species. However, *M. leucoxyla* has performed the poorest of the three plants over the years. 27% of vendors have seen a decline in demand for this plant due to the use of other plants in the market.

In order to determine the sales of each species, it was necessary to find out in which units the plants were purchased and sold. The plants were purchased in local units of "atado" which is represented by a fistful of the plant tied with a rope or lace, “atado” can be translated to English as "tied" due to the physical depiction of the plant, “atadito” also exists as a unit which stands for small “atado”. The "atado" of *Equisetum bogotense* weighs 130 g, *Juglans neotropica* 150 g and *Myrcianthes leucoxyla* 80 g. Vendors then

sold them by the handful or divided the large atado into two small ones. The price is given in Colombian Pesos (COP), which at COP 5,000 are worth around 1 Euro (EUR).

Equisetum bogotense from all selected plants was the most sold. If the sellers did not collect or grow it themselves, it gave them a zero purchase price. They bought Colla de caballo for COP 400 to 4,000 and their gross margin averaged COP 2,500 per day with the most frequent value of COP 2,000 (see Figure 10). The highest selling prices were recorded in Pasto and Medellín.

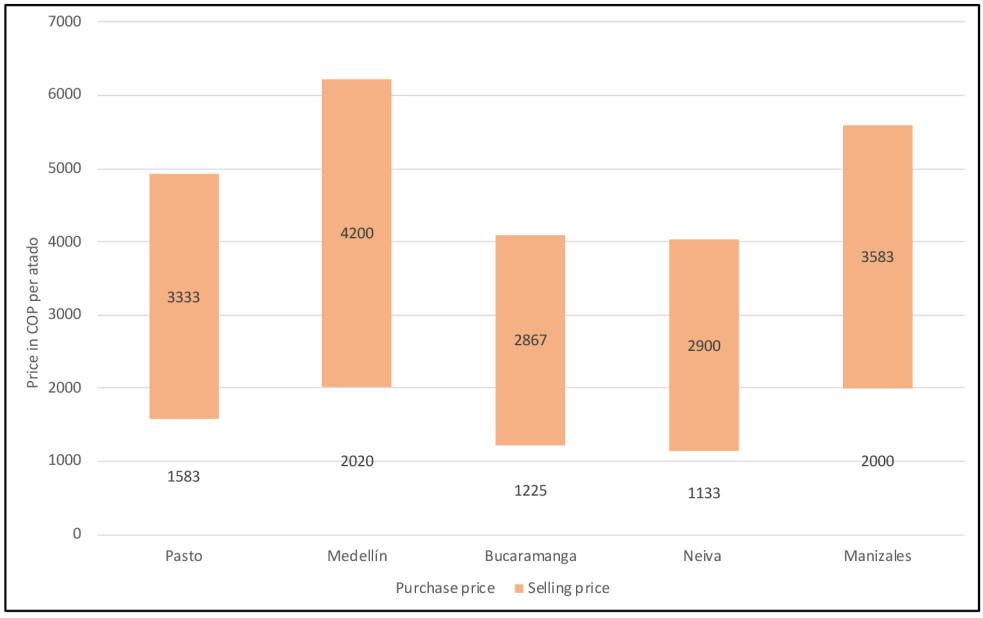


Figure 10. Purchase and selling prices of *Equisetum bogotense* for one atado
Note: COP 5000 corresponds to approximately EUR 1
1 atado of *E. bogotense* = 130g

Since *Juglans neotropica* was sold much less than horsetail on average, its daily profit also decreased. Its average daily profit was most frequently COP 1,500. However, sellers could earn more on sold atado than Horsetail (Figure 11). Its highest selling price reached COP 10,000 by one vendor in Medellín. However, most commonly, COP 2,000 was earned per atado sold.

Similar was the case with *Myrcianthes leucoxyla*, where reporting daily gross margins as the least sold plant was problematic. In contrast, it recorded the highest profit per package (Figure 12). Herbalists earned an average of COP 3,000 per atado from buying and selling this plant. The purchase price per package when selling branches and leaves was usually around COP 2,500. The vendors earned up to COP 2,000, while the gross profit from the bark sale could reach COP 3,600.

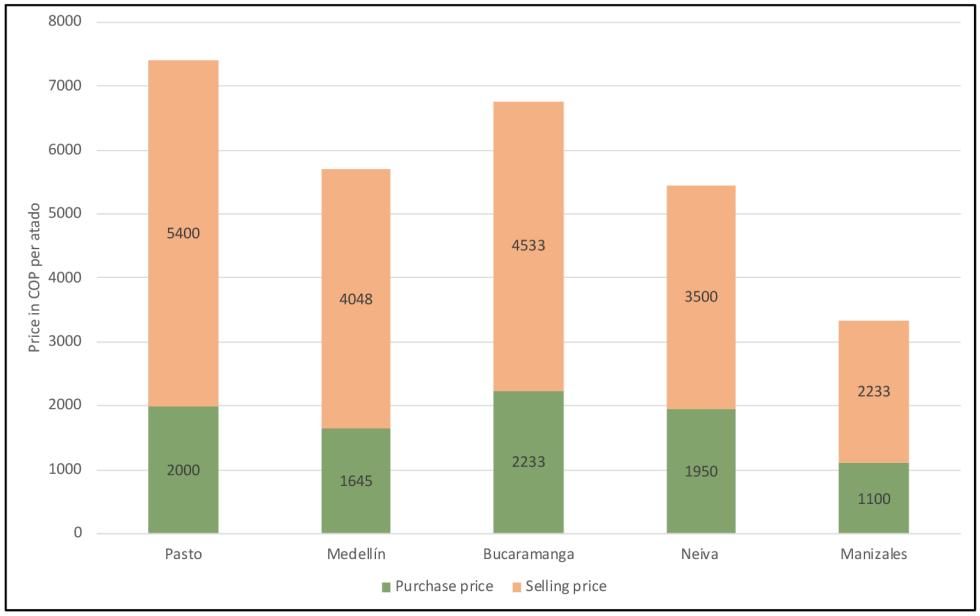


Figure 11. Purchase and selling prices of *Juglans neotropica* for one atado by cities

Note: COP 5000 corresponds to approximately EUR 1
1 atado of *J. neotropica* = 150g

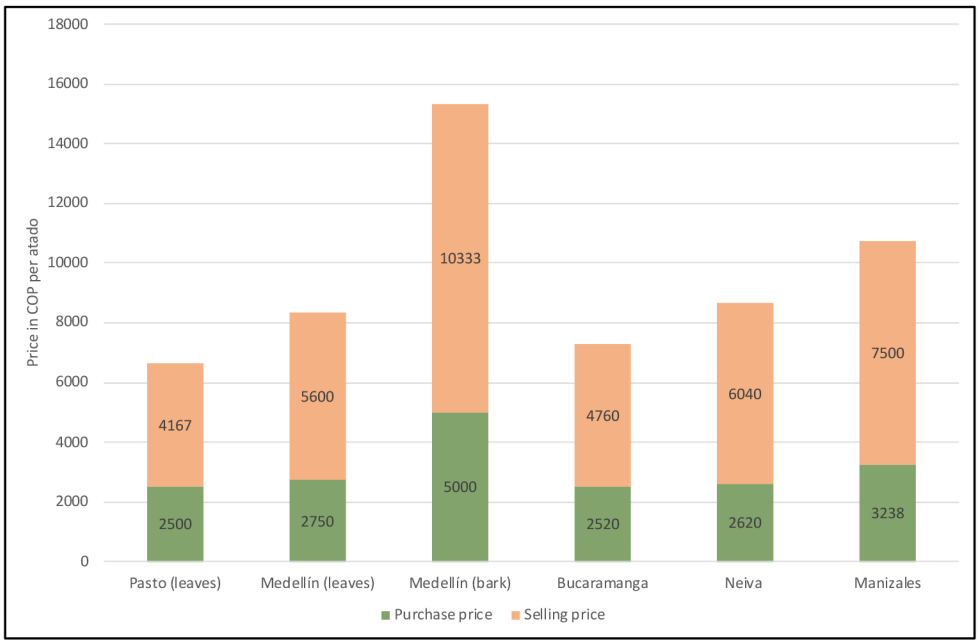


Figure 12. Purchase and selling prices of *Myrcianthes leucoxyla* for one atado by cities and plant part

Note: COP 5000 corresponds to approximately EUR 1
1 atado of *M. leucoxyla* = 80g

In total, these three local species could earn herbalists up to 17% of their minimum monthly income on average, not including other costs. The minimum gross monthly income the Colombian Ministry of Labour calculated for 2023 is COP 1,160,000.

Local units were converted to grams, and the relationship between price per gram in COP and grams of plant sold per day was observed. Through this correlation model is seen the representation of one gram of the plant in the vendors' income. Nevertheless, the relationship was not strong in *E. bogotense* and *M. leucoxyla*, when the correlation was calculated, and the results are statistically insignificant (p-value > 0.05) for both of these species. The only statisticaly significant data held *J. neotropica* (p-value<0.05). Most of the sellers reported selling 180g of *E. bogotense* per day on average. However, it is seen that the price in COP per gram varies widely. In Figure 13 are three large groups in 0.003, 0.004 and 0.006 COP/g. On the plot are also visible a few scattered points, yet the exactness is still acceptable. Some dots exceeding 0.1 COP/g are punctual cases where the seller's characteristics can rely on the size of the city.

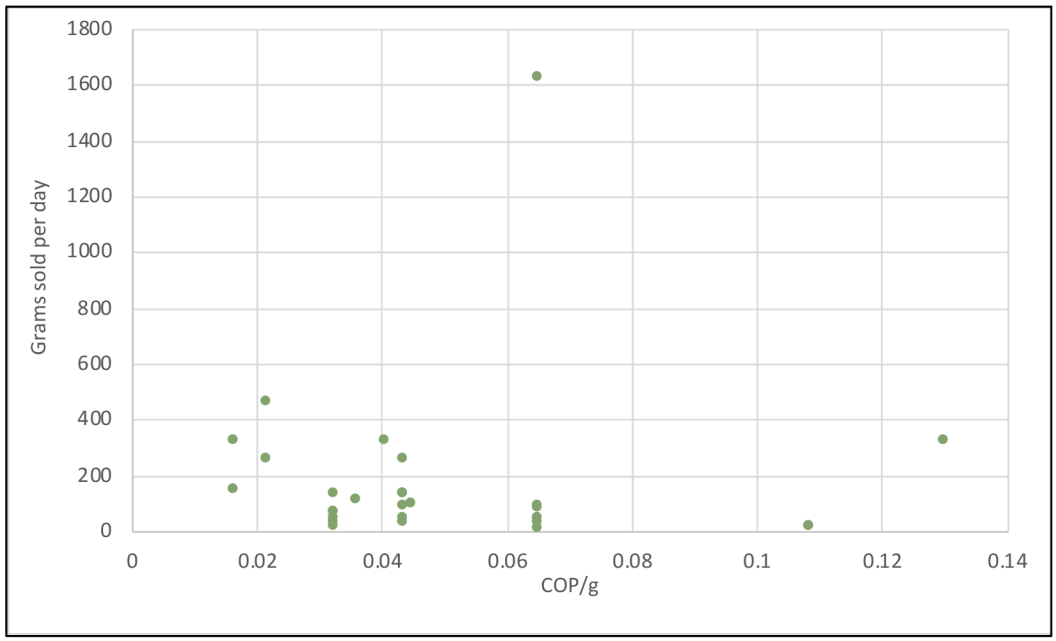


Figure 13. Representation of one gram of *E. bogotense* in the vendors' income

Correlation coefficient = 0.02; p-value = 0.9
Note: COP 5000 corresponds to approximately EUR 1

The *J. neotropica* variation range was also pretty low from vendor to vendor, [0.015:0.08] on average (Figure 14). Most of the vendors recorded to sell generally between 45 to 400 grams daily, the scattered and off-range dots represent bigger vendors or places located in cities with higher demand. Therefore, the product is also more expensive.

The depiction of the *M. leucoxyla* bark is quite different from the previous species. A low variation in grams is related to a large variating COP/g, even though a small group

is seen between 0.1 and 0.2 COP/g, the scattering represents a large variation in the grams sold per day vs the value in COP/g, meaning tat even in the same city, the sellers do not share similar rates and prices. A different case is seen in the *M. leucoxyla* leaves (Figure 16). The prices per gram are significantly lower compared to the bark of the same plant. A scattered behaviour is also seen.

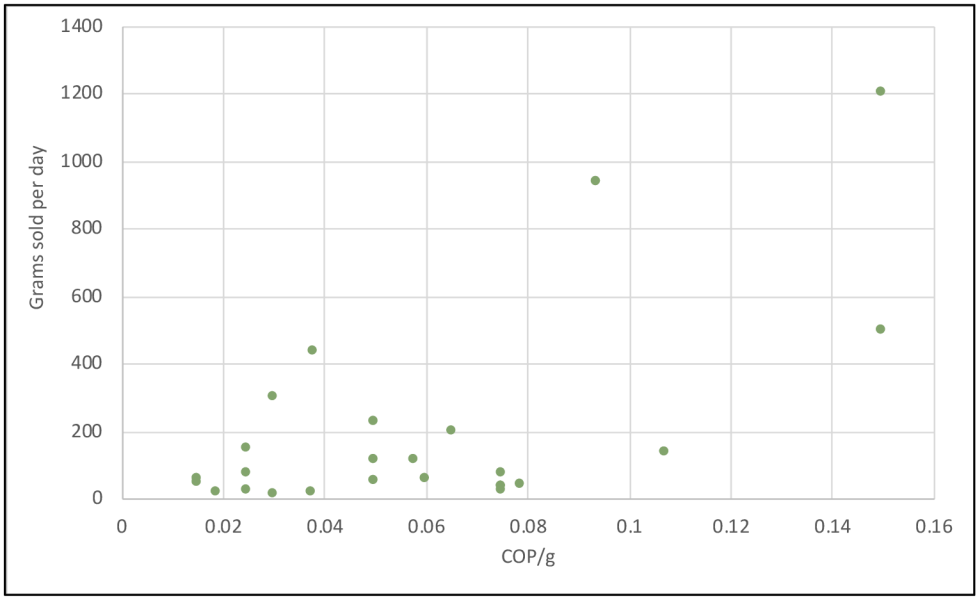


Figure 14. Representation of one gram of *J. neotropica* in the vendors' income

Correlation coefficient = 0.62; p-value = 0.001
Note: COP 5000 corresponds to approximately EUR 1

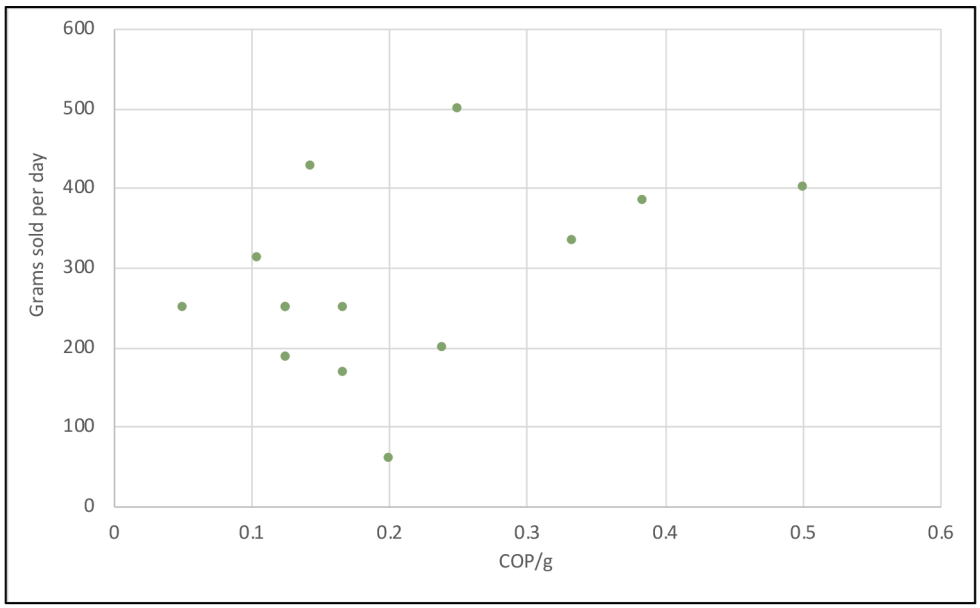


Figure 15. Representation of one gram of *M. leucoxyla* in the vendors' income (bark)

Correlation coefficient = 0.41; p-value = 0.13
Note: COP 5000 corresponds to approximately EUR 1

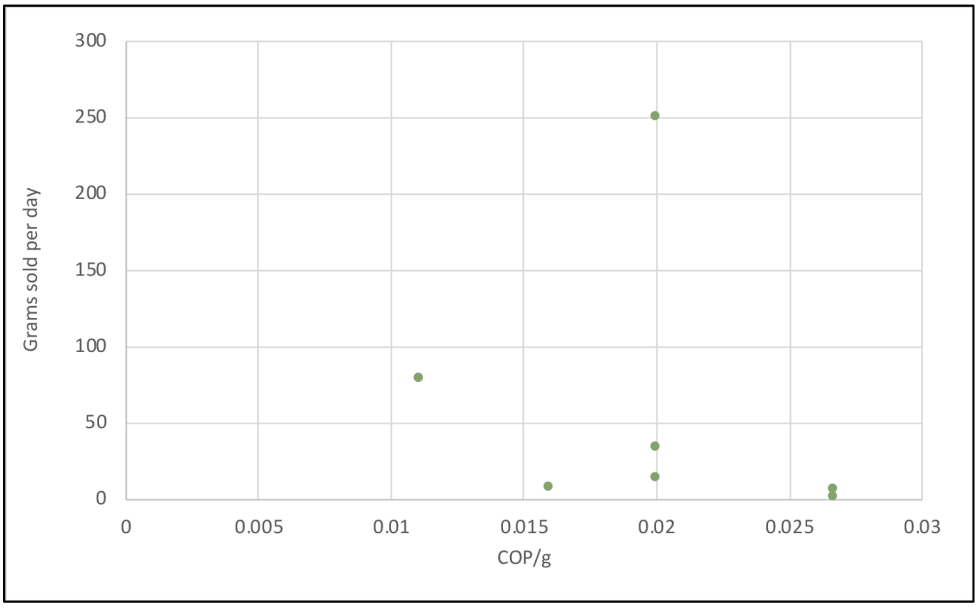


Figure 16. . Representation of one gram *M. leucoxyla* in the vendors' income (leaves)

Correlation coefficient = -0.23; p-value = 0.6
Note: COP 5000 corresponds to approximately EUR 1

To meet customer expectations, vendors keep a certain amount of products in stock. Used correlations are visible in Figures 17, 18, 19 and 20. A predictive model was unnecessary for any of the plants because the stock amounts and sold amounts per day could be defined as a stochastic process. Hence, in the next part, the plots are analysed solitary.

Cola de caballo displays a spread behaviour in terms of atados sold per day and atados in stock (as seen in Figure 17). The majority of the vendors sell less than 4 atados per day; nevertheless, the stock quantity widely ranges. There was found to be a low correlation coefficient between atados in stock and atados sold per day. Simultaneously, the relationship demonstrated a low statistical significance (p-value > 0.05).

The Nogal displayed a variating number of atados sold per day, the atados in stock seemed to be normally between double to triple the amount sold a day (Figure 18). There was find higher correlation coefficient (0.68) and the p-value depicted a statistical significance (p-value < 0.05). A couple of dots exceeded the main group of the *J. neotropica* situation, these points represent bigger sellers which also provided in-market trade, hence, the values depicted elevated behaviour.

Regarding the leaves of Arrayan, it is seen that stock was rather low (Figure 19). A different case was noticed in the bark, where the stock amount was given by the vendors

in kilos. The resultant amount of stock was high, providing a continuous supply with an in-stall reserve (Figure 20). However, the relationship, described by the correlation coefficient, was in both cases low. For the leaves, it reached the value of 0.14 and for the bark,0.25. There was no statistical significance in both selling froms (p-value > 0.05).

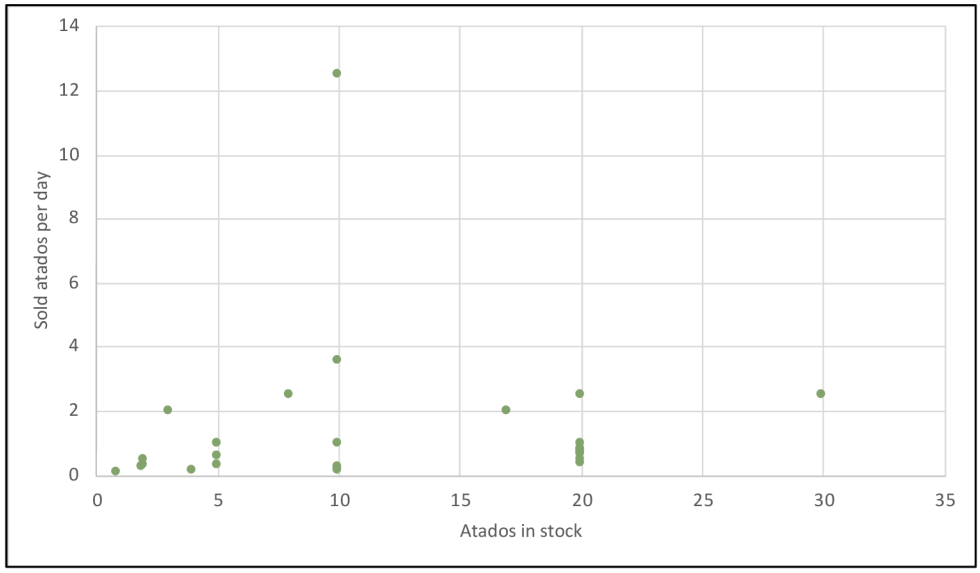


Figure 17. Dependence between the amount of *E. bogotense* sold and the amount in stock

Correlation coefficient = 0.07; p-value = 0.072
1 atado of *E. bogotense* = 130g

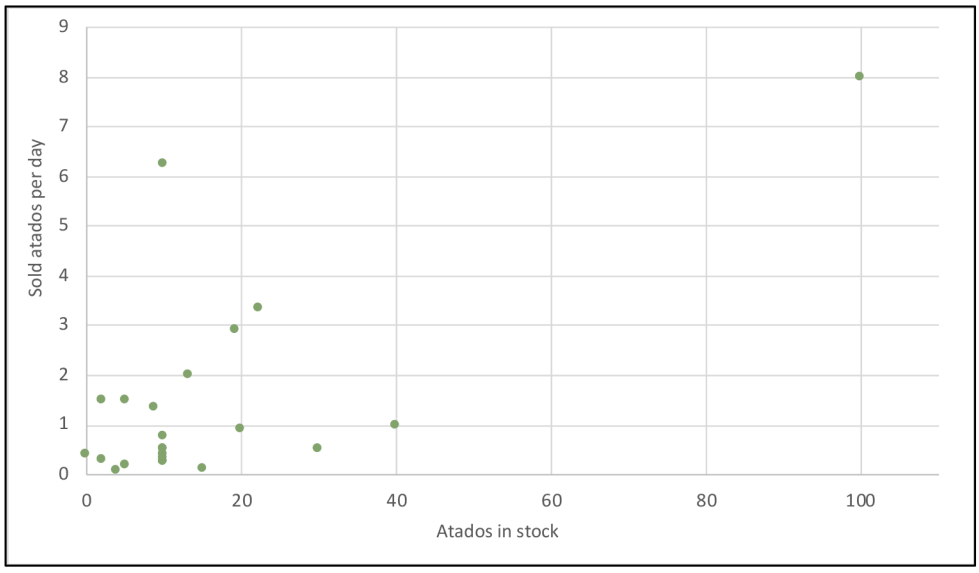


Figure 18. Dependence between the amount of *J. neotropica* sold and the amount in stock

Correlation coefficient = 0.68; p-value = 0.001
1 atado of *J. neotropica* = 150g

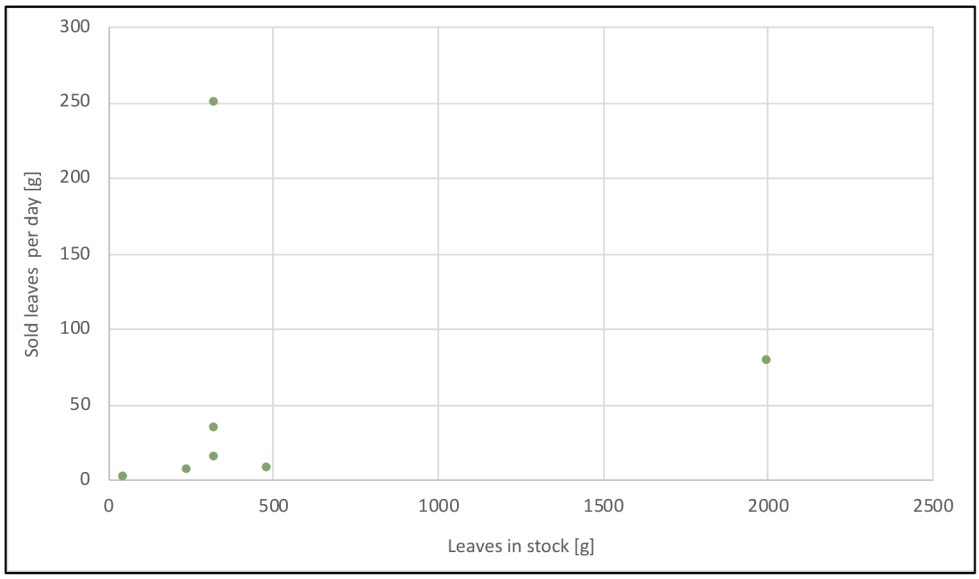


Figure 20. Dependence between the amount of *M. leucoxyla* sold and the amount in stock (leaves)

Correlation coefficient = 0.14; p-value = 0.76

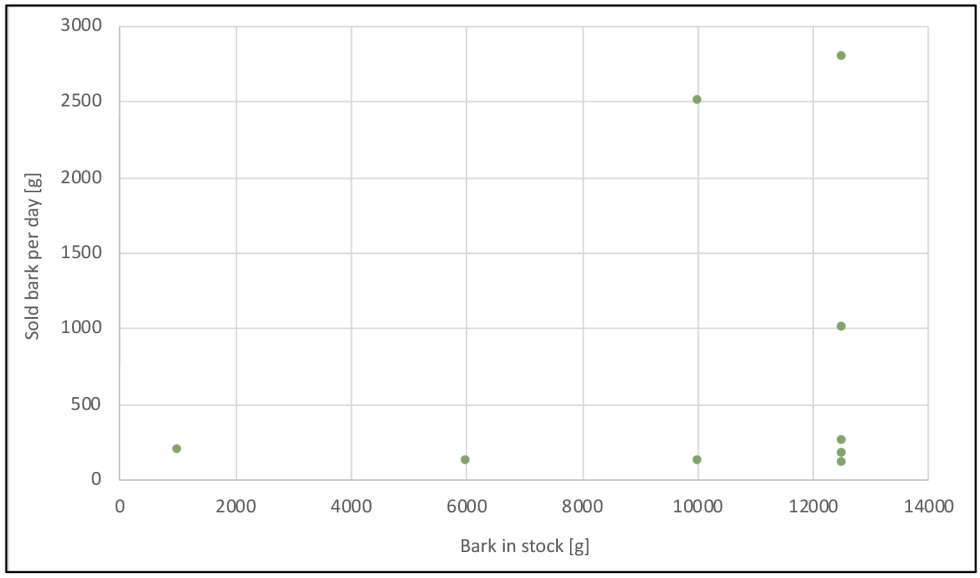


Figure 19. Dependence between the amount of *M. leucoxyla* sold and the amount in stock (bark)

Correlation coefficient = 0.25; p-value = 0.50

5.3.2. Vendors' attached prices and current trade perception

For most vendors, selling medicinal plants was their main occupation (84%); for the rest (16%), selling herbs comprised 50-80% of their total income, and their alternative jobs were in construction, administration, or agriculture. Their stalls were open every day of the week (97%), mainly during the mornings, all year round. They had between 8 to 100 customers a day, and on average, they provided up to 50 people a day, but the most

frequent visit value was 30. They served the most people on average per day in Neiva, where the number of customers at any one vendor did not fall below 20 per day.

Although 83% of the respondents were stall owners, they all had to pay rent to the market's administration office, which ranged from COP 1,100 to 120,000 per meter-square (EUR 1 to 43) monthly, with an average of over COP 21,000 (EUR 4). The size of the stall exhibited statistical significance (p-value < 0.05) on the rent, as displayed in Figure 21. The city with a higher correlation coefficient (= 0.97) between size and stand cost was Medellín, where same time, were found the highest prices overall.

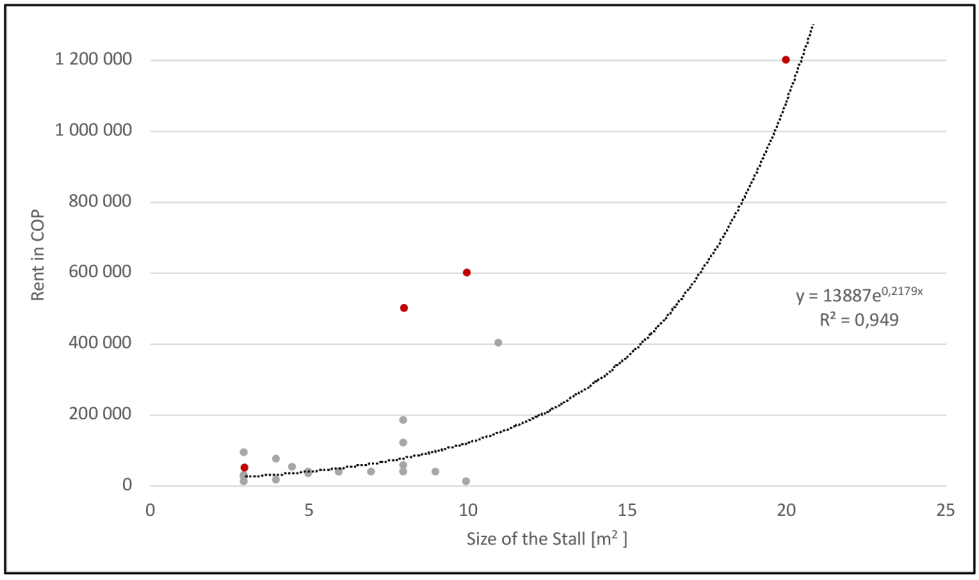


Figure 21. Dependence between the size and price of the stand

Correlation coefficient = 0.88; R^2=0,94; p-value = 0.001

Note: Red dots indicate selling stalls in Medellín
COP 500,000 corresponds to approximately EUR 1,000

Figure 21 indicates a fee corresponding to the area of the stand and allows to predict the size vs rent value with the obtained exponential regression, with an R^2 of 0.94, the curve's equation $y=13887e^{0.2179x}$ permits to find the rent value (y) for any given stall size (x) and also to interpolate for any size in the x-axis range. The 94% of the total variability of the price is being explained by the stall size, meaning that the model is accurate and realiable.

A Likert scale was used to collect data about vendors' difficulties associated with their business over the years, which allowed us to track their choices regarding decisions related to plant sales (Figure 22). Special regard was taken on difference after Covid 19.

Relatively small changes were found between vendors. The pandemic contributed positively to attract customers, with 37% of vendors agreeing. On the other hand, 30% of vendors noted deciding on delivery time as one of the more difficult items today. Other items stayed for the most part unchanged.

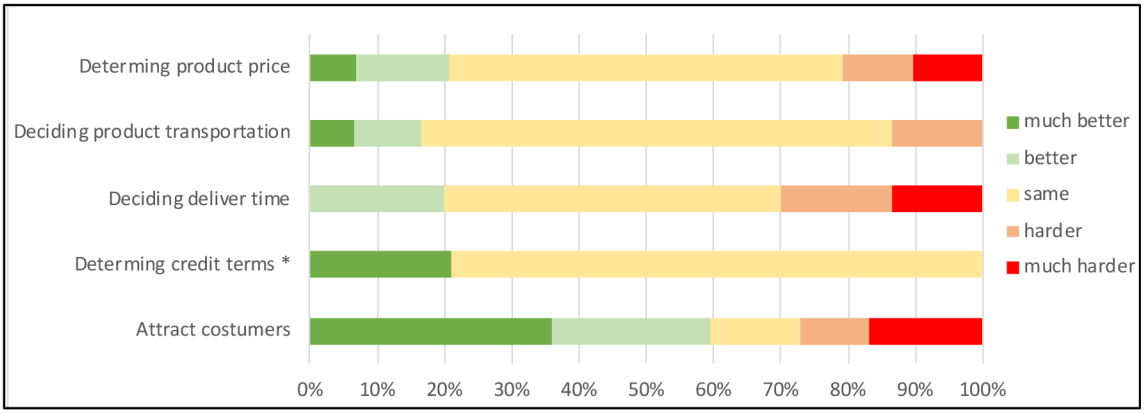


Figure 22. Possibilities for vendors' decision making
*Determining the credit terms refers also to payment delays

Given the long-term presence of sellers in the same market, they could also characterize what changes have occurred in relation to the sale of plants over a longer period of time. To make it easier to describe the situation, also for this part Likert scale was used, which allowed us to clearly describe their experience. The most common responses involved that the price of herbs had increased or that they faced more difficulties in obtaining plants. The majority of sellers (59.38%) reported that medicinal plant sales had increased after the Covid-19 pandemic (see Figure 23). Survey questions regarding the medicinal plant market and the impact on the vendors were related to the differences in prices for collection, transportation, purchase, processing, storage of

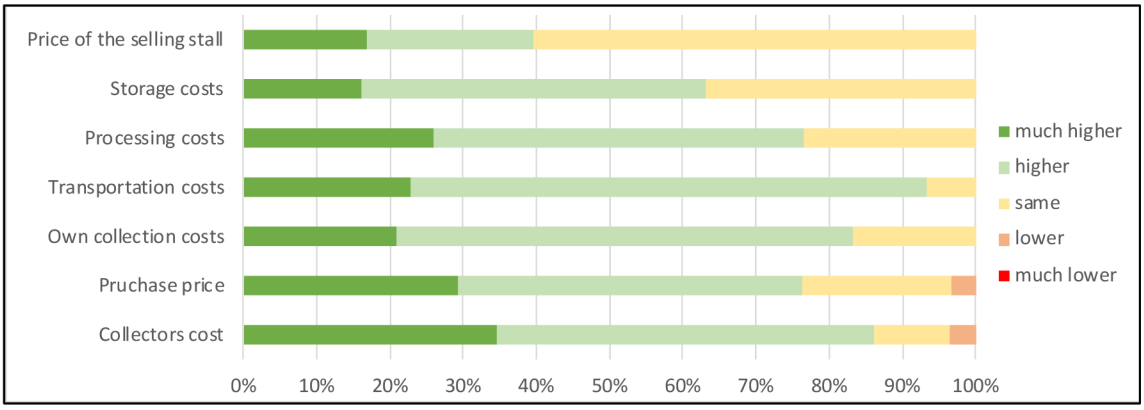


Figure 23. Costs connected to herbal trade after Covid 19

medicinal plants and the expenses spent on their stall. With the exception of the stall fee, the expenses increased or increased significantly after Covid-19. For other items, prices had increased but were still affordable for the vendors.

5.3.3. Vendors' knowledge inheritance and plants utilisation

The following part of the questionnaire were vendors asked about their experience and achieving knowledge regarding medicinal plants. They were selling herbs from 2 to 70 years, and even from 73% at the same market throughout the whole time. They mostly came to this profession thanks to their family, 45% of their mother (Figure 24). The family also played a leading role when trespassing the medicinal knowledge when more than 80% of respondents learned their profession from their relatives.

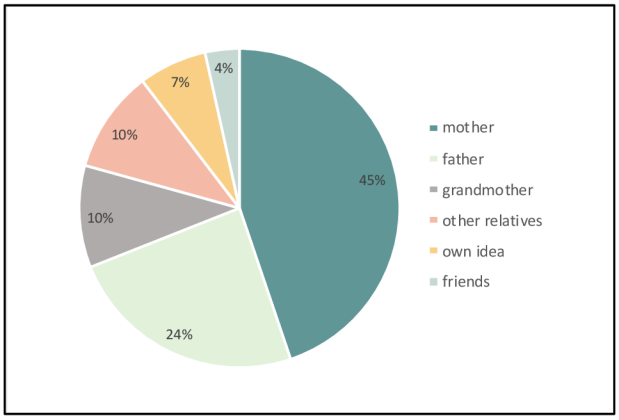


Figure 24. Knowledge inheritance

6. Discussion

6.1. Composition of the herbal market and its globalisation

Despite the Andes being one of the most biologically rich and diverse places on Earth (Myers et al. 2000; Dunstan et al. 2012; Harvey et al. 2020; Comer et al. 2022), the findings of this study indicate that the best-selling medical species does not necessarily correlate with the number of native species in the area. In the study of Bussmann et al. (2018), reporting medicinal plant market in Bogotá was reported that within 20 highest cited species was 45% introduced. Another study describing overall plant diversity in Colombia (Bystriakova et al. 2021) mentioned that from 4200 gathered beneficial pants species, 82% of medicinal plants were native. Moreover, the study on medicinal markets in Peru (Bussmann 2013) displayed that from 31 species that accounted for 50% of sales, 16 were introduced. Nevertheless, these different results do not explain why 71% of the most sold plants are introduced in our study. One of the possible answers could be market globalization. The traditional makets globalization is supported by more ethnobotanical studies that find introduced species even in places with high biodiversity due to modernization and its economic approach (Bussmann 2013; Kunwar et al. 2013; Xu & Xia 2019).

Among the medicinal plant families are the most worldwide common Asteraceae and Lamiaceae, one of the largest families overall (Gras et al. 2021). However, the composition of the families may vary from place to place according to the cultural background and specie diversity (Thomas et al. 2009). Studies conducted in the Andes dealing with medicinal plants supported our range of plant families and pointed out Asteraceae as the most widely used (Macía et al. 2005; De-la-Cruz et al. 2007; Thomas et al. 2009; Luziatelli et al. 2010; Bussmann et al. 2015).

The resulting preference of the individual medicinal species is also generally favourable, as the top five most common species cover a vast range of health problems. *Calendula officinalis*, *Mentha spicata*, *Mentha* x *piperita*, *Matricaria chamomilla* and *Ruta graveolens* are commonly used as antiepileptic, anti-inflammatory, antioxidant, antimicrobial, analgesic, and to treat gastrointestinal or respiratory illnesses and many

others (Gholamipourfard et al. 2021; Mahendran et al. 2021; Bokelmann 2022; El Mihyaoui et al. 2022; Abdelwahab et al. 2022; El Joumaa & Borjac 2022; Dhama et al. 2023). Their effects have the potential to help against the diseases that have caused the most deaths over the last 20 years, according to World Health Organization, which are ischaemic heart disease, stroke, and lower respiratory infections (HWO 2020).

6.2. Major uses categories and economic value of three preselected specie

Through the HWO databases, can be tracked the most common causes of death in each country. The most common causes are more or less the same as those mentioned in the previous paragraph. In Colombia, for 2019, the listed causes in all age categories can be seen in Figure 25 (HWO 2019). Thus, it agrees with our study's results, as the selected species were known to be positive bioactive agents for these specific diseases.

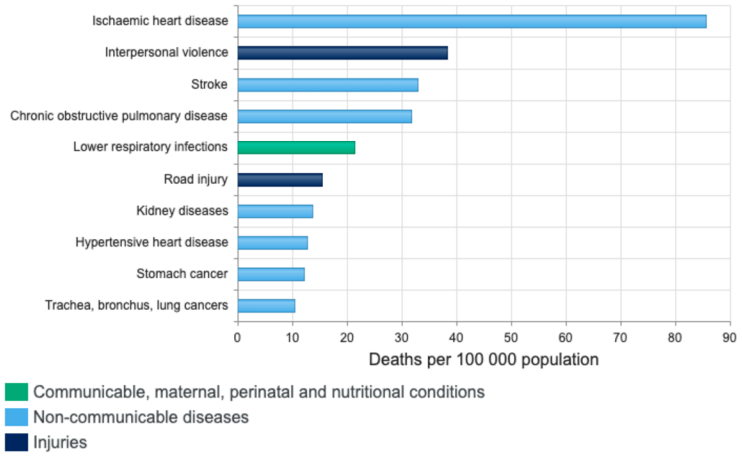


Figure 25. Top 10 causes of death in Colombia

Source: WHO (2019)

This study did not have sufficient data to compare specific health disorders. It only demonstrated the expected results from medicinal plant reviews found in scientific databases, expanding the very small number of scientific papers on these plants' properties, effects and uses (WOS). However, diabetes and the urinary system have been demonstrated by other much larger and more comprehensive studies using Informat Consensus Factor conducted in other countries. Quantitative ethnobotanical studies in Pakistan (Awan et al. 2021), Nepal (Bhatt et al. 2021), India (Bhat et al. 2021) or Indonesia (Husaini et al. 2022) have identified these diseases as among the highest ICF

values. Within the observed usage categories appeared non-specific symptoms which described the traditional application of the herbs most commonly connected to hair growth and hair care. The record of medicinal plants concerning this usage holds more than 300 results in the Web of Science database, and this kind of application was also found in the study of Bussmann et al. (2018) conducted also in Colombian markets.

The results showed that as demand decreased, the price per quantity sold increased, as in *Myrcianthes leucoxyla*. These economic characteristics of plants can be interrelated in many ways. The first possibility is that in order to compensate for an excess demand for a particular species, they cut their losses with a higher price per unit (Andreyeva et al. 2010; Cole et al. 2011). Another option is that the product may have been less available and scarce. However, there needs to be more data to draw this conclusion. As evidenced by many vendors, the final option concludes that other more readily available plants can be used for the same health disorders. Among such, vendors have given the example of different plant specie used instead of *Myrcianthes leucoxyla* or *Juglans neotropica*. Four vendors recommended Chaparro rojo (*Curatella americana* L. for its benefits connected to diabetes. *Curatella american*a is a tree species with similar effects and modes of administration. Its bark is prepared as an infusion and used for oral ingestion (Lopes et al. 2016; Barbosa et al. 2022; Cruz et al. 2022).

The results of the stock survey that vendors hold show large differences between the quantity sold per day and the stock levels. From *E. bogotense*, vendors sold less than 4 atados per day; nevertheless, the stock quantity widely ranged. This can be related to the difficult process of acquiring the plant or even the selling competition and challenges within the market between sellers (Othman et al. 2021). The value doubled to triple higher than the amount sold atados per day was seen in *J.neotropica*. This could illustrate that this specific plant's supply chain happens faster than the Cola de caballo. But this does not correspond with previous results dealing with a decrease in customer interest in this plant. Overstocking was reported in the study of Mati & De Boer (2011) where detected a higher amount of medicinal plants in stock is present in the species imported to ensure a steady supply to the customers. The phenomenon of the mentioned study could be adapted since our research is spoken about local species. Since introduced species are less accessible, we can evaluate that even though our selected species are of local origin, they are less accessible, and thus the stocks are larger. The same could be applied to *M.*

leucoxyla, especially to the bark. Most of the vendors responded that the bark was not only more difficult to obtain but also, due to its large mass and occupied volume when packed, the deliveries were carried out less often (Miththapala 2006).

6.3. Vendors'socio-economical background and knowledge

It is worth mentioning that most of the sellers were women. Many studies have dealt with this subject, aiming to unify and make a balance between the professions and the type of gender (Begossi et al. 2002; de Carvalho Nilo Bitu et al. 2015; Delbanco et al. 2017; Singh et al. 2022; González-Ball et al. 2022; Chaachouay et al. 2022; Seile et al. 2022). They aimed to define the problems associated with this occupation as vendors. The reason why more women dominate medicinal plant markets may be diverse. However, one explanation emerges from studies by Seile et al. (2022), González-Ball et al. (2022), Singh et al. (2022) or Chaachouay et al. (2022) performed in numerous parts of the developing world: Africa, Latin America and Asia. In these studies, it was reported that women oweral and indigenous women carried much more indigenous knowledge in the field of healing and plant identification than males. This statement can also be corroborated by our knowledge inheritance survey, where it was shown that more than 55% of the sellers acquired their knowledge from their mother or grandmother.

Our respondents were mainly older, which may indicate that they have acquired more knowledge over their years in the market (Pereira et al. 2005; Borba & Macedo 2006; Ashagre et al. 2016; Singh et al. 2022; González-Ball et al. 2022). However, another angle may be that the sellers have a healthy lifestyle and use medicinal plants to their advantage. When the vendors were asked whether they use the three selected plants, 53% answered in the affirmative, along with their entire family. The low prevalence of young respondents may also be a result of a lack of interest among young people in the field, or a desire to provide higher income for their families since most of the sellers in our study belonged to the lower socio-economic class (Chaachouay et al. 2022).

From our results, it could be said that there are several factors as age, time on the market, education, gain of knowledge regarding medicinal plants and socio-economic class in correlation and relationship to one another (Schupp et al. 2021). As the sellers were born into the first and second "strato socio-economico" they had to begin helping

the family and secure financial resources as soon as possible. The parents, most often the mother, worked as herbalists and trained their son or daughter in this trade. The descendants graduated only from primary school, and even if they wanted to start a more profitable profession, they would not have succeeded due to their low education degree. Furthermore, the vendors do not possess the availability to obtain credit to finance their education or develop their business. Moreover, if they do, the educated youngsters do not continue in their family profession. This situation leaves the family in a lower socio-economic class, and their primary source of income is the sale of plants. That reflects the situation of the 6.6% of the population in Colombia that falls into the lower income category estimated by The World Bank (2021). With these difficulties operated several studies aiming to describe the economic situation in various professions (Adhikari 2012; Njaya 2016; Truong 2018; Wallace et al. 2022). The resultant approach of these studies mentions that there could be an improvement from the side of the governments to provide training programmes for their business skills and improve their economic knowledge.

6.4. Current trade perception and difficulties

Colombia possesses a good health care system and puts up to 8% of its GDP into it (WHO 2022; The World Bank 2022). Healthcare is paid according to personal income. Thus, people from lower socio-economic classes can afford it (Espinosa et al. 2022). Nevertheless, the fact that for 84% of vendors, selling plants is the primary source of livelihood means that society is constantly craving traditional medicine. The possible reasoning highligted research of Alwis et al. (2021). which describes in the state of art the tradition of medicinal plant usage and its cultural importance. This statements supports many other ethnobotanical studies concerning medicinal plant usage within markets and communities (Lulekal et al. 2008; Behailu & Temesgen 2017; Assefa et al. 2020; Bhat et al. 2021). For addition, Delbaco et al. (2017) mentioned in their research that sometimes medicaments obtained by conventional medicine could promote discontent and are perceived as unsafe and inefficient as well as they are ont affordable for people with a lower economic background.

According to the results of this study, there was an overall increase in sales after the Covid-19 pandemic and positive change in the way of attracting costumers. Since Covid-19 was initially shrouded in uncertainty over how to control it, many people may

have turned to traditional medicine in their impatience to obtain a treatment (Boukhatem & Setzer 2020; Benkhaira et al. 2021). This awareness and its prospect prompted other scientists including pharmacologists to focus their research on exploring medicinal plants to counter the pandemic (Tahir Ul Qamar et al. 2020; Benarba & Pandiella 2020; Oladele et al. 2020; Adhikari et al. 2021).

6.5. Recommendations for future research

Based on the findings of this study, we would like to extend a recommendation to the government and relevant stakeholders as the main actors involved in the commercialization. Large support should be provided in continuing research concerning medicinal plants' diversity and their trade in local Colombian markets. It would be appropriate to contribute to the individual objectives of this study not only in the mentioned cities but even more in smaller cities, villages or communities that rely on the use of traditional knowledge so programs of promotion, health and others could somehow attain a linking bridge. We suggest conducting a more in-depth analysis of the top-selling species to provide a broader quantitative ethnobotanical study that will not only help to understand the effects of the plant and to update the literature but a large popularization in regions with similar climate and flora could use this knowledge to improve their living conditions. At the same time, a value chain study could be performed for certain species. This would reveal in more detail how the product is marketed and highlight opportunities and possibilities to improve sales of native species. From a social point of view, it would be helpful to find out more about the impact of traditional medicine not only on sellers but also on customers. Thus, a customer survey could be a further objective of the study.

6.6. Study limitations

Our study is not without limitations that could affect the results and findings. Firstly, the data was collected over a month without considering the seasonality of species in the market. As with all survey studies, there may have been the possibility that vendors only communicated partially clear and reliable information regarding personal interview questions. This situation may have occurred primarily when respondents were unaware of the answers to our questions and tried to comply with our answers. Lastly, comparisons

between cities would require visiting more respondents and markets to be able to draw results with greater confidence. Also, seeing that Colombia is a large country, focused research zone by zone could deeply characterize the use of the plants depending on the region, tradition and society.

7. Conclusions

This Masters's thesis documented eight herbal markets in the Colombian Andes and interviewed 30 vendors. The research came to the following conclusions. Firstly, the majority of the 55 most commercialised medicinal species sold in the herbal markets in the Colombian Andes were introduced and originated outside the Americas. Secondly, the three preselected species of local origin could be considered underutilised even when their therapeutic purposes could threaten common medical disorders for native people. However, the profitability of the species is not insignificant and could potentially account for 17% of the vendors' minimum salary range. Moreover, vendors acquired their knowledge of medicinal plants through their families. Lastly, the respondents perceived an overall increase in both customer amount and plant sales after Covid-19.

This thesis was the first rapid rural appraisal embracing an extensive range of information linking the economics and ethnobotany of medicinal species. It contributes to understanding the connection between commerce and cultural knowledge and emphasises the importance of future research in this direction.

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Appendices

List of the Appendices:

Appendix 1: Semi-structured questionnaire

Questionnaire: Ethnobotanical survey and commercial trends of herbal species in Colombian Andes

City: _____ Vendor n. _____, contact: _____

Chapter I – Vendors (characteristics and sales management)

Gender	[choose answer]	male ☐ female ☐
Age	[years]	
Origin (where were you born/grown up)?	[answer]	
For how many years are you already selling herbs?	[years]	
For how long do you work/sell herbs here at this market?	[years]	
How did you come to this profession/how did you started? Who inspired you?	[choose answer / multiple choice]	family ☐ friends ☐ own idea ☐ project ☐ other ☐ specify:
How did you acquire the knowledge about medicinal plants?	[choose answer]	family ☐ friends ☐ own idea ☐ project ☐ other ☐ specify:
Is selling plants your primary/most important job?	[choose answer]	yes ☐ no ☐
What is the share of selling plants on your total income?	[answer, % of income]	
Family status	[choose answer]	married ☐ single ☐ in partnership ☐ widowed ☐ divorced ☐
How many people live with you in (your) household?	[number]	
What is your estrato socio economico?	[number]	
Education	[years of schooling] [highest finished]	
Do you observe any changes during the years of selling herbs at this market? Which?	[open-ended]	
How many people is usually come and buy from you plants per one day?	[number]	
How often do you sell plants in the year?	[choose answer]	Whole year ☐ During high/harvesting season only ☐; Rush months: ..... ☐
What is the frequency of sales / being at the market?	[choose answer]	7 days/week ☐ 3-4 days/week ☐; 1-2 days/week ☐
Are you owner of this stall?	[choose answer]	yes ☐ no ☐

Selling barriers		NOW	BEFORE Covid
The price is now .. [much higher - 0; higher 1; same - 2; lower - 3; much lower - 4] *[is much better = 0; better = 1; same = 3; harder = 4; much harder = 5]	Collectors asking high price Purchase price from collectors Your own collection costs Transportation costs Processing costs Storage costs Price of the selling stall Attract costumers * Determine the credit terms to the buyer (payment delay) Decide when the product is delivered * Decide how the product is delivered Decide the amount to be paid for the product		

2rd Part – Plant no.1

		Nogal	Cola de caballo	Arrayán
What plant part are you selling?				
For which purpose(s) are you selling this plant?				
Sold fresh or dried? Or processed? [fresh=1, dried=2, both = 3 other processing=3]				
If fresh, how long can it stay fresh? [days]				
How is it received?/administration [oral=1, rubbing=2, washing=3, bath=4, compress=5, decoction=6, inhalation=7]				
What is the dosage? [units]				
Are you collecting the plant? [vendor=1, some else did=2 - if – who?]				
Does it grow wild, or it is cultivated? [wild=1, cultivated=2]				
From where the plant is shifted? [Origin]				
Through which way is it transported from collector to you? [bus=1, your car=2, shared car=3, other=4]				
How often is the plant delivered to you?				
In what units is it imported to you, and at what price?				
In what units do you sell and at what price?				
How much do you have it usually in stock?				
How much do you sell per day?				
What amount a costumer is usually buying per visit? [units]				
How many costumers is coming usually in a week? [de ja vu]				
Who are the most common customers who buy the pant? [males=1, females=2; both = 3]				
Is there some change of demand in last year? [1=more, 2=same, 3=less]				
Reasons for that? [open]				
Are you using this plant? Or your family?				