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Chapter

Collection, Storage and Market of Medicinal Plants: A Case in Peru

Juan F. Seminario, S. Berardo Escalante, Rosel Orrillo-Mejía and Karina Malca-Quiroz

Abstract

There are few studies on the collection and market of medicinal plants in South America and particularly in Peru. Through a review of secondary sources, information is gathered on the use and market of medicinal plants, and information is provided on the collection, collection and market of medicinal plants in the department of Cajamarca, focused on a chain of value of fresh plants (57 species) and another of dry plants (37 species), which mainly supply coastal markets. It is also reported on the collection in the first months of the COVID19 pandemic. The species come mainly from the Quechua region (2300 to 3500 masl), 51% are wild and the others are cultivated or weeds. Its main threats are mining, agricultural expansion, overgrazing, burning of natural vegetation, and over-harvesting. The monetary value of these plants is approximately US $ 804,333.64/year. In the first months of COVI19, the demand for eucalyptus, matico, chamomile and husk increased, mainly, and prices rose by more than 200%. Value chains are informal, they add minimal value to products, with the predominance of the interest of wholesale collectors.

Keywords: traditional medicine, medicinal plant market, value chain, high mountains, Peru, COVID19

1. Introduction

In Peru 80% of the population uses phytotherapy as a medicinal resource, 76% of population insured by EsSalud (a health system for state employees) are willing to receive treatment with medicinal plants, and about 90,000 insured people per year, use complementary medicine (CM) services in 83 CM care centers In addition, despite of being a multi-diverse country, no attention has been paid to the development of medicinal plants value chain, pointing out as some of the greatest challenges, the proper registration of these plants, the protection of their biodiversity, investment in research and the guarantee of quality and safety when being used [1].

On the other hand, the growing demand of medicinal plants has generated problems regarding their future availability, because most of them are collected from nature (minimal cultivation), without any type of adequate management guaranteeing the long-term sustainability of the extraction and the *in-situ* species preservation [2].

Cajamarca region's land (Peru) is an important area for the collection, production, use and market of medicinal plants with pre-Inca heritage and is part of the

Northern Peruvian *shaft of health* extending towards Ecuador and Bolivia [3, 4]. In this report, based on the South American context, we approach the study of medicinal plants in Peruvian markets, particularly in Cajamarca, describing collection and stockpiling of fresh and dried medicinal plants in two provinces capital, giving place to two informal value chains. The results of an observation on the collection of medicinal plants during the first months of the COVID-19 pandemic in these two markets are included.

2. Use and market of medicinal plants in South America

Inventories of medicinal species by countries in South America are insipient and the estimates indicate about 23,403 species (**Table 1**), from 50,000 to 80,000 medicinal species (flowered) estimated for the world [14]. These approaches leave many questions to be resolved in the future. For example, it is estimated that Peru has 1400 medicinal species [15]. Then, the estimate was more than 3000 species with this use, and 774 medicinal species in current use were described with 343 pharmacological actions [5]. In South America, Colombia is the country that has best documented the medicinal species used in their pharmacopeia and has established strategies and guidelines for their knowledge, conservation and sustainable use [6].

South America cities continue to use medicinal plants, as their first alternative in health treatment; however, in few cases complete studies were done on markets supply (**Table 2**). Exits a lack of studies on the subject in most of South American cities. A comparative study in three countries (Colombia, Peru and Bolivia) indicates that only 4% of species and 1% of genera in the markets are shared [16].

3. Studies on medicinal plants in the markets of the cities of Peru

We do not have a complete vision of the agribusiness for medicinal plants in Peru because the studies in these cities' markets are still incomplete (**Table 3**). The few studies are focused mainly to identify the species marketed and to establish their use.

Country	No. species	No. families	Source
Peru	> 3000	nd	[5]
Colombia	2404	202	[6]
Ecuador	3118	206	[7]
Bolivia	3000	102	[8]
Chile	781$^{\Delta}$	nd	[9]
Brazil	1500$^{\bullet}$	148	[10]
Argentina	9000$^{\lozenge}$	nd	[11]
Paraguay	600	nd	[12]
Uruguay	249$^{\blacksquare}$	nd	[13]

nd: no data.
$^{\Delta}$*It refers to edible wild plants only, which are also medicinal. Detailed information exists for 120 species.*
$^{\bullet}$*Includes species which there is information on use and pharmacology.*
$^{\lozenge}$*Chemical, pharmacological and toxicological studies: 121.*
$^{\blacksquare}$*Species on sale in authorized stores. The informal sale of these herbs is prohibited in this country.*

Table 1.
Number of medicinal species and families from south American countries.

City/country	No. species	No. families	Source
Valencia, Carabobo, Venezuela	84	45	[16]
Caracas Venezuela	164	72	[17]
Pernambuco, Brazil	169	70	[18]
Cuarto Río, Córdova, Argentina	125	48	[19]
Rio de Janeiro, Brazil	376	94	[20]
La Paz and El Alto, Bolivia	163	58	[21]
Loja, Ecuador*	160	57	[22]
Bogota, Colombia	409	nd	[23]

nd: no data.
**33 traditional markets in the province of Loja, southern Ecuador were included.*

Table 2.
Number of medicinal species and families in markets in South America cities.

City	No. species	No. families	Source
Corongo	70	32	[24]
Jauja	45	nd	[25]
Cusco	152	45	[26]
Ayacucho	66	30	[27]
Huaraz, Yungay and Carhuaz	178*	44	[28]
Cajabamba	123	49	[29]
Trujillo and Chiclayo	400	118	[30]
Cajamarca	470	129	[31, 32]

nd: no data.
**incluyó pequeñas comunidades.*

Table 3.
Registries of medicinal species and families in markets of cities in Peru.

The issue has not been addressed from the perspective and concept of the value chain [33, 34]. Commercialization of medicinal plants in Quero and Masma Chicche communities (approximately 3500 to 4800 masl), Masma Chicche district, province of Jauja, department of Junín was studied following the route of the gatherers - growers and the other actors in the chain to the cities of Jauja and Lima. Through interviews and direct observation, it was determined the links in the chain that includes gatherers-producers, intermediaries, processors (small, medium and large), retailers and consumers. In addition, it was found that the chain has added a little value, it mainly offers primary transformation products (creams, extracts, flours and syrups) made with artisanal methods. There are no formal relationships between the actors in the chain, most of the plants are collected and cultivation is incipient [25].

Studies of medicinal plants, carried out with semi-structured interviews and direct observation, in the commercial town of Ayacucho (highlands of Peru, approximately 240,000 inhabitants) highlight the presence of 66 species, between cultivated and wild. The most important volume sales corresponded to matico, manzanilla and ortiga. The species with the highest cultural value were ruda macho (*Ruta graveolens* L.), ruda hembra (*Ruta chalepensis* L.) and honojo (*Foeniculum vulgare* Mill.); those with the highest economic value were muña (*Satureja brevicalyx* Epling), manayupa and ruda hembra. The estimated total volume was 163.6 t/ year, which represents a monetary value of 409,602.7 soles/ year (US $ 117,361.8/year) [27].

The most in-depth studies on medicinal plants in the Peruvian markets were carried out in the north of Peru and correspond to the RW Bussmann group. In one of them [35], through collections made in the fields, markets and the house of healers in northern Peru (Piura, Lambayeque, La Libertad, Cajamarca and San Marín), 510 species from 126 families (83% native) of medicinal plants used to treat 20 groups of diseases were identified. This study not only shows a 2000-year timeline of healing culture in this region, but also the importance of the mountains of Cajamarca and particularly the surroundings of the city of Cajamarca as a supplier of medicinal plants for these markets. The following studies aimed to establish the relationship between the plants found in the Trujillo and Chiclayo markets and the collection and storage sites [36, 37], as well as the relationship between collection and cultivation of medicinal plants and the supply of these markets [38].

Subsequent research analyzes the relationship between the market, healers, vendors and collectors and the sustainability of the use of medicinal plants in northern Peru [30]. A meticulous review of the species used in northern Peru and southern Ecuador, with all their changes since the colonial era, was also made [4]. After more than a decade of work, one of the latest studies [39] points out that the increase in the demand for phytosanitary products does not increase their cultivation. On the contrary, its greatest threat is the disturbance of high ecosystems and calls into question the sustainability of the cultivation, use and market of medicinal species. Likewise, it is estimated that the value of medicinal species in the markets of northern Peru is 1.2 million USD/year. Recently, other studies on this topic were summarized in Cajamarca, focused on specific geographic areas and the ethnobotany of species [40, 41].

4. The market for medicinal plants in the city of Cajamarca

Cajamarca is located in the north of Peru, in South America. It is the center of a large region, made up of the departments of Tumbes, Piura, Lambayeque, La Libertad, Amazonas and San Martín. This region is considered a *shaft of health* (**Figure 1**, shaded area), which, since antiquity, share traditions, knowledge, natural resources, particularly medicinal plants, healers and shamans. At the same time, this center has close ancestral relationships with Ecuadorian and Bolivian populations regarding diagnosis, treatment and cure of diseases [3, 4]. Most of the Cajamarca land (with 13 provinces) is located in the high mountains, another part in upper rainforest (Jaen and San Ignacio) and a small area on the coast (Contumazá). Two informal value chains for medicinal plants are being developed in this area. One in the city of Cajamarca (**Figure 1(1)**), for fresh plants and the other in the city of San Marcos (**Figure 1(2)**) for dry plants. Both, supply the markets of eight cities located in the coast (**Figure 1(3)**–**(8)**) and one in upper rainforest - Nueva Cajamarca- (**Figure 1(9)**).

Cajamarca city, capital of the department, is located at 2700 masl and 859 km from Lima, the capital of Peru. It was important since Inca times and here the meeting between European and Andean culture took place in 1532. Currently it has a population of 225,800 inhabitants and its immediate surroundings are made up of 12 eminently rural districts. The city of San Marcos is the capital of the province of the same name (with seven rural districts), located 62 km from the city of Cajamarca, it has an approximate population of 9500 inhabitants [42].

Our team carries out research on medicinal species in the Cajamarca city market since 2003 and we have observed the changes that have occurred in the last two decades [31, 40, 41, 43, 44]. Among other aspects, the market for medicinal plants has grown significantly. Thus, in 2003 the city was supplied with 305 species (94



Figure 1.
Shaft of health *area of northern Peru ([3] modified) indicating the collection and storage centers and targeting markets of the medicinal plants stockpiled in Cajamarca, Peru.*

botanical families) and in 2018, 470 medicinal species were on market (129 botanical families). Here it is included eight new medicinal species incorporated into the market over the past two decades: *Estevia rebaudiana* Bertoni (estevia), *Salvia hispánica* L. (chía), *Moringa oleífera* Lam.(moringa), *Morinda citrifolia* L. (noni), *Azadirachta indica A.Juss.* (nin), *Hibiscus sabdariffa* L. (Jamaica), *Vaccinium corimbosum* L.(arándano) y *Phalaris canariensis* L. (alpiste). The number of herbal stalls (from 8 to 27) and stores of processed products (from 3 to 29) also grew. The collection points fell from 8 to 4, but the number of stockers increased from 8 to 18 and the stockpiling days, from two (Monday and Friday) to three (Monday, Thursday and Friday).

The city receives fresh, dried and processed medicinal plants from the mountains, coast and rainforest. A significant part of the fresh plants come from the communities of the surrounding districts. In this report we refer in a special way to this part of plants, with an emphasis on stockpiling to supply the coastal markets. The value chain (**Figure 2**) of these plants collected on the heights of Cajamarca, until it reaches local consumers or other cities is informal, with actors loosely connected and which, prevailing interest from the wholesale stockers of the Coast. The links involved are described below.

The **gatherer-producer** is the one who collects wild medicinal plants and *arvenses* (weeds) or grows and harvests them in their gardens. *Arvenses* are plants that grow spontaneously in crops (and in fallow land), are tolerated and encouraged in their first stage and then are used as fodder, food or medicine. Collection is carried out mainly by women and children and is encouraged by the growing demand for consumption in the cities and by the need of families to increase their economic income. It is a secondary activity carried out while grazing animals or while doing work on the crops. After harvesting, bundles or thirds that have an average weight of 0.350 kg are formed, placed in cloths or plastic containers and transferred to the market. Most of the gatherers sell their product to local stockers and others are gatherers-stockers, who collect and buy from their neighbors and take the product to the coastal markets.

No technical criteria related to the conservation and sustained use of the species are applied, nor is it necessary to have a State collection permit. The collectors say that "it was always like this." Even when the promotion and sustainable use of medicinal plants, in harmony with the environmental, social, health and economic interests of the Nation, is legally regulated [45]; so far, the State has no direct intervention in this matter.

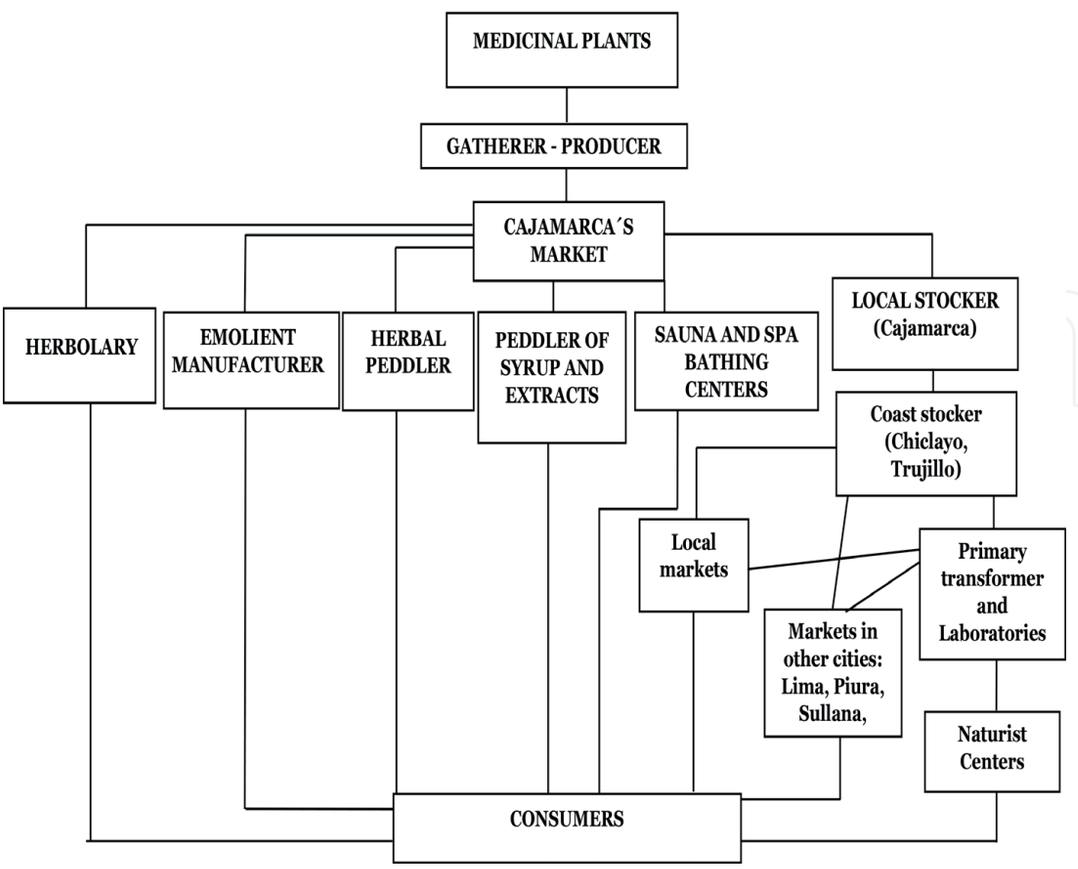


Figure 2.
Scheme of the informal value chain of medicinal plants collected in the city of Cajamarca, Peru.

The **intermediates** are the link between the gatherer-producer and the user, and there are several types: herbalist, emollient manufacturer, peddlers of aloe extract, syrups and other extracts, peddlers of fresh and dried plants, sauna and spa bathing centers, gyms with sauna bath service and the local stocker. The first three have been reported in detail in previous investigations [41, 43, 44]. Next, we will refer to the last four.

- **The peddler of syrups and extracts.** This is a businessman that emerged in the city of Cajamarca in the last two decades [40]. The vendor equipped with a wheelbarrow or cart travels the area surrounding the city market, offering handcrafted preparations to heal illnesses. Customers approach the cart and ask for a preparation (which usually includes a pharmacy product) according to their condition. During one day, this vendor can serve 122 clients, with 14 different illnesses. In this group, sellers of *tocosh* are included, which emerged in the city in the last decade. Tocosh is a traditional product that is obtained by hand, through the bacterial fermentation of potatoes (or corn) in tanks, placed in streams or pools of water, until it becomes a mass, from which the water and the remains of the tuber (skin) are removed and, dried in the sun. This product is highly nutritious and rich in penicillin, recommended against infections, gastritis and ulcers. Animal laboratory studies have shown to possess antioxidant activity, cytoprotective to and regenerative gastric mucosa [46, 47].

- **The peddler of fresh and dried herbs.** It is an outpatient herbalist, with no fixed location point offering fresh and dried herbs, preferably species of the eastern Peru (Amazon, San Martin, Loreto, Ucayali), combined with Cajamarca species. It also offers artisan preparations of plants, "made at the moment" [31, 40].

- **The sauna baths and the** *spa.* These centers consume as yet undetermined amounts of medicinal and aromatic plants on a daily basis. In the cities of Cajamarca and Baños del Inca (located 5 km from the city of Cajamarca), there are 18 *spa* centers, 14 sauna and *spa* bathing centers and 4 gyms with sauna bathing service. Some are part of the hotel service and others are independent. The largest, which provides services (thermal bath, sauna, hydromassage) to significant numbers of tourists is the Baños del Inca Tourist Center, administered by the district Municipality of Baños del Inca. This center is a main point of the tourist circuit of the city of Cajamarca, which, in 2018, received more than 900,000 tourists [48]. In a telephone interview with nine administrators of these centers, it was found that the species used are eucalipto (*Eucalyptus globulus*), manzanilla, romero (*Rosmarinus officinalis*), rosa (*Rosa* sp.), toronjil (*Melissa officinalis* L.), hierba luisa (*Cymbopogon citratus* (DC.) Stapf.), jengibre o kión (*Zingiber officinale* Rosc.), canela (*Cinnamomum verum* J. Presl), ruda (*Ruta graveolens* L.), molle (*Schinus molle* L.), sauce (*Salix* sp.), geranio (*Geranium* sp.), té verde (*Camellia sinensis* (L.) Kuntze) y sábila (*Aloe vera* (L.) Burm f.). On average, they buy 1.3 soles day from one to two species and in three cases they partially supply themselves from their own garden.

- **The local stocker of medicinal plants.** This character is an intermediary who collects fresh medicinal plants in the city for sale in markets along the coast. Other agents, including primary transformers and laboratories, depend on this link until the plant reaches the final consumer (**Figure 2**, right). They are mostly women between 40 and 55 years old, all with experience in the business of more than 10 years. They are located in certain streets and points of the city

and wait for the gatherers-producers who come from the surrounding communities (Monday, Thursday and Friday). They buy until they collect the largest possible volume, place the herbs in bags of approximately 50 kg and ship them by truck to the markets of Chiclayo and Trujillo (**Figure 1(3, 4)**). In these cities there are wholesale stockers that collect large volumes of each species, dehydrate them and distribute them to various destinations: local markets in the city and its districts; laboratories that process medicinal plants in the same city and in Lima; markets in other cities such as Lima, Piura, Sullana and Tumbes (**Figure 1(5)–(8)**) and healers and shamans as well.

5. Cajamarca as a supply center of medicinal plants for the market

5.1 The collection of fresh medicinal plants in the market of the city of Cajamarca

5.1.1 Scope of gather and storage

The gatherers-producers come from the Cajamarca district and districts surrounding the city of Cajamarca such as Baños del Inca, Llacanora, Jesús, Chetilla, Magdalena, Llacanora, Namora and La Encañada; belonging the same province. The main communities where the collection is carried out are Pariamarca, Huambocancha, La Laguna, Jesús, San Juan, Chotén, Chigdén, Higuerón, Yumagual, Gavilán, Huayllapampa, Agocucho, Cumbico, El Cumbe, La Encañada (several communities), Huanico, Baños del Inca (several communities), Cerrillo, Chetilla (several communities), Otuzco (several communities), Miraflores, Huacataz, La Colpa, Cruz Blanca, Llacanora (several communities), Porcón, Porconcillo, Chamis, Aylambo, Choropunta, Secsemayo and Tual. These communities are included in the Yunga Alta, Quechua and Jalca regions, between 2200 to 4200 masl (with a predominance in Quechua, 2300–3500 masl). The gatherers-stockers, who bring medicinal plants directly to the coastal markets, from certain communities, are excluded. For example, those that are on the coastal route such as San Juan, Chigdén, Yumagual, Higuerón, Chotén. This collection and direct shipment also occur in the capitals of districts like Jesus, Llacanora, Namora and Matara.

Although collection and stockpiling of medicinal plants has been developed for several decades in these areas, currently its main threat is metallic and non-metallic mining, since 66% of the territory of this province is under concession to this activity [49]. For now, three major centers of collection and storage (Combayo, La Encañada and Chanta Alta) stopped working, because they are mining areas. Other factors are the expansion of the agricultural frontier, overcollection, overgrazing and the burning of natural vegetation (an ancestral practice of the peasants that has the purpose of promoting the regrowth of the vegetation that serves as pasture).

The first study on the gather of fresh medicinal plants in the market town of Cajamarca was made early in the decade of 2000 [43] when the city had 125,000 inhabitants and began a stage characterized by revaluation of traditional medicine and the consumption of organic products. Sixty-six species were collected for the local and coastal market, coming from the communities near the city, with an average of 5702 kg/month.

Five years later, the ambulatory marketing of medicinal plants was observed on Revilla Pérez de Cajamarca street and two types of vendors were identified; the unskilled who arrived every day and sold, in addition to medicinal plants, other plants (spices, vegetables, ornamentals and fodder) and; the specialized ones, who arrived

on Mondays and Thursdays and only bought and sold medicinal plants. The latter were the stockers who collected large quantities to send to the coastal markets. They observed 42 stored species (34 native), 26 collected, not cultivated. The most common were manzanilla, orégano, culantro (*Coriandrum sativum* L.), ruda y perejil [38].

A recent evaluation of the collection indicates that in the city of Cajamarca 57 medicinal species are stored, in the fresh state (28 families) (**Table 4**), which are then transported to Chiclayo and Trujillo. Sixty five percent of the species are native to the Andes, there was prevalence (46%) of leaves as part used; 25 are cultivated and 14 are wild; the others share wild-weed and cultivated-weed states, so that most are collected [31, 40].

Species of the Quechua region (2300–3500 masl) are predominant (47%), only four are exclusive to Jalca. List does not include Jalca species as chinchimalí (*Gentianella* graminea (H.B.K.) Fabris), trenza (*Hupersia* sp.), estrella (*Phyllactis rigida* (Ruiz & Pav.) Pers. maqui maqui (*Loricaria ferrugínea* (Ruiz & pav.) Wedd.), lengua de ciervo (*Campiloneurum angustifolium* (Sw) Fée.), pachachancua (*Satureja nubigena* (Kunth) Briq.), carnero (*Puya hamata* L.B.Sm.), condor (*Huperzia crasa* (H. & B. ex Willd. Rothm.) purunrosa (*Bejaria aestuans*), órnamo (*Valeriana* sp.), andacushma (*Geranium sessiliflorum* Cav.) y romero de jalca (*Clinopodium sericeum* (C.Presl ex Benth.) Govaerts) and; other lowland species as san pedro (*Echinopsis pachanoi* (Briton & Rose) Friedrich and G. Rowley), sábila (*Aloe vera* (L.) Burm. f.) y flor blanca (*Iresine weberbaueri* Suess), which were identified in high demand in previous studies [50]. These species are collected and shipped, at strategic points, directly to the markets of the coast.

5.1.2 Main species according to the volume of collection.

If we take into account the 10 most collected species, during a day, a gather can collect 180 bundles of manzanilla, 80 bundles of valeriana, 60 bundles of pie de perro and so on, up to a minimum of 35 bundles of menta [31, 40]. So, in order to gather significant quantities, a buying and selling system is established, between gatherers, where each one seeks his objective at the end of the day. The first two species have not changed in their relative importance compared to 2003 (**Table 5**). However, the following eight species have varied in their relative importance and none is repeated. This situation is explained by the changes in the demand for the species and also by the new collection and shipping points for the coast. Other studies are not comparable, as they paid more attention to the most common species that are sold daily for local consumption, in which, prevail food species as perejil, ruda, paico (*Dysphania ambrosoides* L.) and chancua and; aromatic herbs such as cedrón, culantro, hierba luisa, menta, romero, orégano y toronjil. The formers are used to make the *green broth,* a traditional plat of frequent consumption in the city [38].

5.1.3 Volume and economic value of the collected plants

An evaluation carried out between 2017 and 2018, in the 18 local stockers, indicated that the total volume of 57 collected species, means 407.03 t/ year of fresh product, more than five times of the collection in 2003. The gather-producer sold at 0.43 ± 0.14 soles / bundle and the Cajamarca stocker sold in Chiclayo at 1.22 ± 0.26 soles / bundle, obtaining a gross profit of 0.79 ± 0.18 soles /bundle. It is to say, the monetary value in the gather-producer of Cajamarca is 500145.93 soles/ year (US $ 143308.29/year) and the monetary value in the wholesale of Chiclayo is 1419018.67 soles (US $. 406595.60. Therefore, the value of fresh medicinal plants collected in Cajamarca, means 33.9% of the total trade, estimated by Bussmann (2013) in the markets of Trujillo and Chiclayo.

Species	Vulgar name	Family	Origin	Biological state	Used part	Region
Artemisia absinthium L	Ajenjo	Asteraceae	I	S, C	Leaf	Q
Cynara scolymus L.	Alcachofa	Asteraceae	N	C	Leaf, Inflorescence	Y, Q
Scabiosa atropurpurea L.	Ambarina	Caprifoliaceae	I	C	Inflorescence	Q
Tagetes filifolia Lag.	Anis del campo	Asteraceae	N	S, C	Foliage	Q
Apium graveolens L.	Apio	Apiaceae	I	C	Leaf	Y, Q
Nasturtium officinale R. Br.	Berro	Brassicaceae	I	S	Foliage	Q, J
Capsella bursa-pastoris (L.) Medik.	Bolsa de pastor	Brassicaceae	N	S, A	Foliage	Q
Borago officinalis L.	Borraja	Boraginaceae	I	C, A	Leaf, flower	Q
Baccharis genistelloides (Lam.) Pers.	Carqueja	Asteraceae	N	C	Leaf	Q
Aloysia citrodora Palau	Cedrón	Verbenaceae	I	C	Leaf	Q
Minthostachys mollis (Benth.) Griseb.	Chamcua/ muña	Lamiaceae	N	S, C	Leaf, stem	Q, J
Fascicularia bicolor (Ruiz & Pav.) Menz	Chochocón	Bromeliaceae	N	S, C	Leaf, stem	Q
Cupressus macrocarpa L.	Ciprés	Cupresaceae	I	C	Foliage	Q, J
Equisetum giganteum L.	Cola de caballo	Equisoceae	N	S	Foliage	Q, J
Oreocallis grandiflora (Lam.) R. Br.	Cucharilla	Proteaceae	N	S	Leaf	Y, Q
Adiantum poiretii Wikstr.	Culantrillo	Pteridaceae	N	S	Leaf	Q,
Otholobium glandulosum (L.) JW Grimes	Culen	Fabaceae	N	S, C	Leaf	Q
Asplenium peruvianum Dev.	Cuti cuti	Aspleniaceae	N	S	Plant	Q
Cheilanthes pruinata Kaul.	Cuti cuti blanco	Pteridaceae	N	S, C	Leaf	Q
Taraxacum campylodes G. E. Haglund	Diente de león	Asteraceae	I	C, A	Foliage	Q
Perezia multiflora (Humb. & Bonpl.) Less.	Escorzonera*	Asteraceae	N	C	Flower	Q, J
Eucalyptus globulus Labill	Eucalipto	Myrtaceae	N	C	Leaf	Q

Species	Vulgar name	Family	Origin	Biological state	Used part	Region
Brugmansia sanguinea (Ruiz & Pav.) D. Don	Floripondio rojo	Solanaceae	N	C	Flower, leaf	Q
Cymbopogon citratus (DC.) Stapf.	Hierba luisa	Poaceae	I	C	Leaf	Y, Q
Foeniculum vulgare Mill.	Hinojo	Apiaceae	I	C	Leaf, stem	Q
Achyrocline alata (Kunth) DC.	Ishpingo amarillo	Asteraceae	N	S	Leaf, stem	Q, J
Gnaphalium dombeyanun DC.	Ishpingo blanco	Asteraceae	N	S	Leaf, stem	Q, J
Plantago major L.	Llanten	Plantaginaceae	I	S, A	Leaf	Y, Q
Alcea rosea (L.)	Malva grande	Malvaceae	N	C	Foliage	Q
Matricaria chamomilla L.	Manzanilla	Asteraceae	I	C	Foliage	Q
Piper aduncum L.	Matico	Piperaceae	N	S, C	Leaf	Q
Origanum majorana L.	Mejorana	Lamiaceae	I	C	Leaf	Q
Mentha x piperita L.	Menta	Lamiaceae	I	C	Leaf	Q, Y
Alternanthera porrigens (Jacq.) Kuntze	Moradilla	Amaranthaceae	N	C	Foliage	Q
Juglans neotropica Diels	Nogal	Juglandaceae	N	C	Leaf	Q
Origanum vulgare L.	Orégano	Lamiaceae	I	C	Leaf	Q
Urtica urens L.	Ortiga*	Urticaceae	N	S, A	Foliage	Q
Plantago sericea Ruiz & Pav.	Paja blanca	Plantaginaceae	N	S, A	Leaf	Q
Clinopodium pulchellum (Kunth) Govaerts	Panizara	Lamiaceae	N	S, A	Plant	Q
Geranium ruizii Hieron .	Pasuchaca	Geraniaceae	N	S	Leaf	J
Petroselinum crispum (Mill.) Fuss	Perejil	Apiaceae	I	C	Leaf, stem	Q, Y
Desmodium molliculum (Kunth) DC.	Pie de perro	Fabaceae	N	S	Foliage	Q
Sanguisorba officinalis L.	Pimpinella	Rosaceae	I	C, A	Foliage	Q
Calceolaria argentea Kunth	Romerito	Calceolariaceae	N	S	Leaf	J

Species	Vulgar name	Family	Origin	Biological state	Used part	Region
Rosmarinus officinalis L.	Romero	Lamiaceae	I	C	Leaf	Q
Ruta graveolens L.	Ruda	Rutaceae	I	C	Leaf, flower	Q, Y
Myrcianthes myrsinoides (Kunth) Griffin	Rumilanche	Myrtaceae	N	S	Leaf	Q
Linum prostatum Dombey ex Lam.	Sangrenaria	Linaceae	I	C, A	Seed	Q
Sambucus peruviana Kunth	Sauco	Adoxaceae	N	C	Leaf	Q, J
Tillandsia sp	Siempre viva	Bromeliaceae	N	S	Leaf	Q
Stachys arvensis L.	Supiquewa	Lamiaceae	N	S, A	Foliage	Q
Caesalpinia spinosa (Molina) Kuntze	Taya	Fabaceae	N	S, C	Fruit, leaf	Y, Q
Melissa officinalis L.	Toronjil	Lamiaceae	I	C	Leaf	Y, Q
Mauria heterophylla Kunth	Trinidad	Anacardiaceae	N	S	Leaf	Q
Valeriana pilosa Ruiz & Pav.	Valeriana*	Caprifoliaceae	N	S	Root-rhizome	J
Culcitium canescens Humb. & Bonpl	Vira vira*	Asteraceae	N	C	Foliage	J
Smallanthus sonchifolius (Poepp.) H. Rob.	Yacón	Asteraceae	N	C	Leaf, root	Q

**C: cultivated; S: wild; A: arvense. N: native, I: Introduced. Y: Yunga, Q: Quechua, J: Jalca.*

Table 4.
List of medicinal plants collected in the city of Cajamarca, Peru: 2017–2018.

2003	2018
Manzanilla	Manzanilla
Valeriana	Valeriana
San pedro	Pie de perro
Eucalipto	Ciprés
Berro	Escorzonera
Laurel	Apio
Flor blanca	Supiquehua
Manzanilla macho (*Tanacetum* sp.)	Alcachofa
Chinchimalí	Nogal
Andacushma	Menta

Source: [31, 43].

Table 5.
Main species, according to the volume of collection in the Cajamarca market: 2003 and 2018.

In this value chain, the least favored agent is the gather-producer, who in some cases is also a local gather. However, their tenure in business for more than 10 years indicates that these agents have attractive incomes. Our inquiries through friendly conversations with gatherers in the city of Cajamarca, indicate that the stockers put into play various strategies that ensure profitable economic income, every time they take or send their products to the coastal markets: they arrange orders from buyers interested in certain species, they direct their attention to the species with the highest demand and whose prices remain more stable, without neglecting to offer diversity; they do not store and do not travel if the market is not good, due to the entry of plants from other areas; they are attentive to the rise in demand and prices of certain species.

This perception is different from that reported by other authors [37], who followed a gather – stocker (Julia) from Chigdén (San Juan district), 37 kilometers from the city of Cajamarca, to the Chiclayo market (Moshoqueque) and estimated that after working for 3 days (from gather and purchase), in the best case (it sold everything) it earned 6.45 US dollars (22.51 soles) and in the worst case scenario (it sold below the average) it earned 2.80 US dollars (9.77 soles). Two questions arise here: Is this a representative case of what happens regularly to gatherers-stockers? And, would it make sense to Julia and her 20 colleagues who did the same, to continue in this business when their earnings are at the indicated level?

Species that achieved best prices (2017–2018) were valeriana and taya, followed by ambarina, bolsa de pastor, alcachofa, apio, manzanilla, orégano, hierba luisa y culén. The last five have dual purpose, are medicinal and both aromatic and, used in teas. The species that generally have the lowest price are eucalipto, ciprés, rumilanche and trinidad. The average sale price of each bundle may be temporarily distorted, due to the rise in the price of a certain product. For example, at one point in the evaluation, the price of the bundle of fresh yacon leaf, paid to the producer, reached S/. 10 and the coast stocker sold it by S/. 25/bundle.

5.1.4 The other links

If the plants are already in the warehouses of the wholesale stockers of the coast one part goes to supply the local markets of the same cities and another, to the markets of other cities such as Lima, Piura, Sullana and Tumbes. A third part is directed to primary transformers and laboratories.

Transformation is one of the fastest growing areas in the country in recent decades. It can be small formal companies that do primary artisanal transformation, such as dehydration, crushing, grinding, juices, extracts and syrups; including packaging and labeling, with minimal quality control. There are cases where, the raw material (medicinal plants) is transported from Cajamarca for 6 to 7 hours to Chiclayo or 18 hours to Lima and then returns billet or shredded, bagged and labeled and, reenters the market the city. There are also medium and large pharmaceutical and organic products companies, with recognized laboratories, located in Lima, which have a sanitary registry and are the ones that process most of the natural products found on the market (syrups, extracts, pills, capsules, gels, ointments, etc.). These companies have grown in number and their presence in the conventional market and online is remarkable. They offer in addition, dried plants and seeds. However, they face the problem of adulteration and counterfeiting of their products. The products of laboratories (formal and informal) in its various presentations, is targeting processed products stores nationwide, known as generically *Naturist centers.* An evaluation in 10 centers (34% of the total) of Cajamarca indicated that there are 202 processed products, which include 170 species (according to label).

In this activity there are two types of small businesses: One sells only laboratory processed products and the other, sells processed products and additionally offers artisan preparations, according to the condition indicated by the client. Processed products can also enter markets through the herbalist's posts and peddlers. The sale of processed products has grown enormously and there are new ventures in distribution and retail sale, and even courses are offered for local entrepreneurs for this purpose.

In Peru, the DIGEMID (General Directorate of Medicines, Supplies and Drugs) is the entity in charge of registering, re-registering, modifying, denying, suspending or canceling the sanitary registration of pharmaceutical products, as well as carrying out the control and sanitary surveillance of the same; in application of Law No. 29459 (2009) on Pharmaceutical Products, Medical Devices and Health Products. Supreme Decree 016-2011-SA (2011) contains its rules. The DIGEMID grants the registration as medicine, to the processed products, which are attributed, at least, a proven therapeutic property, which must appear on the label, in addition to the professional (pharmaceutical chemist) responsible. On the other hand, according to Peruvian legislation [51], natural therapeutic resources have been classified in (1) **Natural Resource for Health Use** (Art. 70)**:** any natural resource (plant, animal or mineral) that has not been processed, chopped, dehydrated or ground, and constitutes the raw material for prepared natural products or preparations. It is admitted that, if the sale label does not contain therapeutic indications, it does not require a health registration. For example, the uña de gato bark, valeriana root, boldo leaves, clay and maca powder. Natural resources are sold without prescription, both in pharmaceutical and commercial establishments, as authorized by the health registry and; (2) **Natural Product for Use in Health** (Art. 71): Simple or complex industrial elaboration, based on one or several natural resources, that uses the isolated or synergistic virtues of said resources, which have an ancestral history of recognition and use among the indigenous populations of one or more national or international cultures. Natural products can be sold with or without prescription, as authorized in the health registry.

The consumer as the final link in the chain has variable behavior, according to their economic power, social position, culture and knowledge. The main type is the one that, when faced with a condition, resorts, in the first instance, to herbs and natural products in general. Buy fresh or dried herbs to prepare at home, guided by his own knowledge or following the recommendations of a neighbor, family member or herbalist. The second type is one that, when faced with a condition, buys and consumes syrups or extracts of artisan preparation, in a peddler or health food store. This guy is increasing, due to the way of life in the city: lack of time to prepare his remedy

(and their food) and because these preparations are cheap. The third type is one who cares for his health and prevent disease through natural products processed with a certain level of assurance, which shows through the brand or label of formal laboratories. He is the typical middle-class client, who goes to naturist centers. The fourth type is the one who, when faced with a condition, for which he has not found a solution, goes to the healer or shaman. He may or may not participate in an allowance, but receives a prescription, which must be applied in the time and in the indicated way.

5.2 Collection of dry medicinal plants in the city of San Marcos (Cajamarca)

5.2.1 Collection and storage

The market for medicinal plants in the city of San Marcos, unlike the market in the city of Cajamarca, is a center for the collection of plants dried under natural environmental conditions (approximately 13–14% humidity). This was studied in two stages: The first between June and December 2017 [31], through semi-structured interviews with four wholesale stockers, direct observation of the collection process in two stockers and, dialogs with gatherers, stockers and a transporter of medicinal plants.

The second stage was carried out between October 2018 and January 2019 in 15 communities of the four most important districts, where the collection is carried out; located between 2250 and 3423 masl (Yunga Alta and Quechua regions). The districts of Chancay, Ichocán and Eduardo Villanueva were not included (it is estimated that in these districts there are at least 10 more communities where collection is carried out). Twenty-two gatherers –12 women- (out of an estimated total of 45) and 11 local stockers –6 women- were included. Semi-structured interviews and direct observation were conducted with two wholesale stockers, and two gatherers were accompanied in their work of collecting and drying plants. More than 50% of the gatherers and stockers were over 50 years old 77% of gatherers had complete or incomplete primary education and; 59% of the stockers had between 4 and more than 6 years in this activity [52].

Collection is carried out in wild areas (which are also grazing), except in three cases (eucalipto, nogal y aliso) it is carried out around the cultivated fields. This dependence on wild areas and the lack of technical criteria on the rates and good collection practices mean that the main threats to the sustainability of the supply are overgrazing, the burning of natural vegetation, the overcollection, expansion of the agricultural frontier and mining [34, 53] --21% of the province's territory was under concession -- [49].

The collected plants are taken home, where they are dried in the shade, until the humidity is balanced with the ambient humidity. In tests carried out with eucalipto y cola de caballo, it was found that the weight losses in drying are 60% and 70%, respectively. In the informal value chain described by the species collected in this market (**Figure 3**), a new destination is added, in relation to the plants collected in the city of Cajamarca. This is the market of the city of Nueva Cajamarca, in the department of San Martín (**Figure 1(9)**). Its agents act with minimal coordination and the interest of the wholesale stockers of San Marcos and the Coast prevails. In all cases, the collection and sale of medicinal plants is a secondary activity in the generation of economic income (the main activity is agriculture-livestock). The income for the gatherers, for this concept, can vary from 100 soles (US $ .29)/year to more than 1000 soles (US $. 287)/year.

5.2.2 The collected species

In this market 37 species belonging to 20 botanical families are collected. Three are trees and the rest are herbs (18) and shrubs (16). Five are introduced from other continents and the rest are native to the Andes. Three are cultivated and the

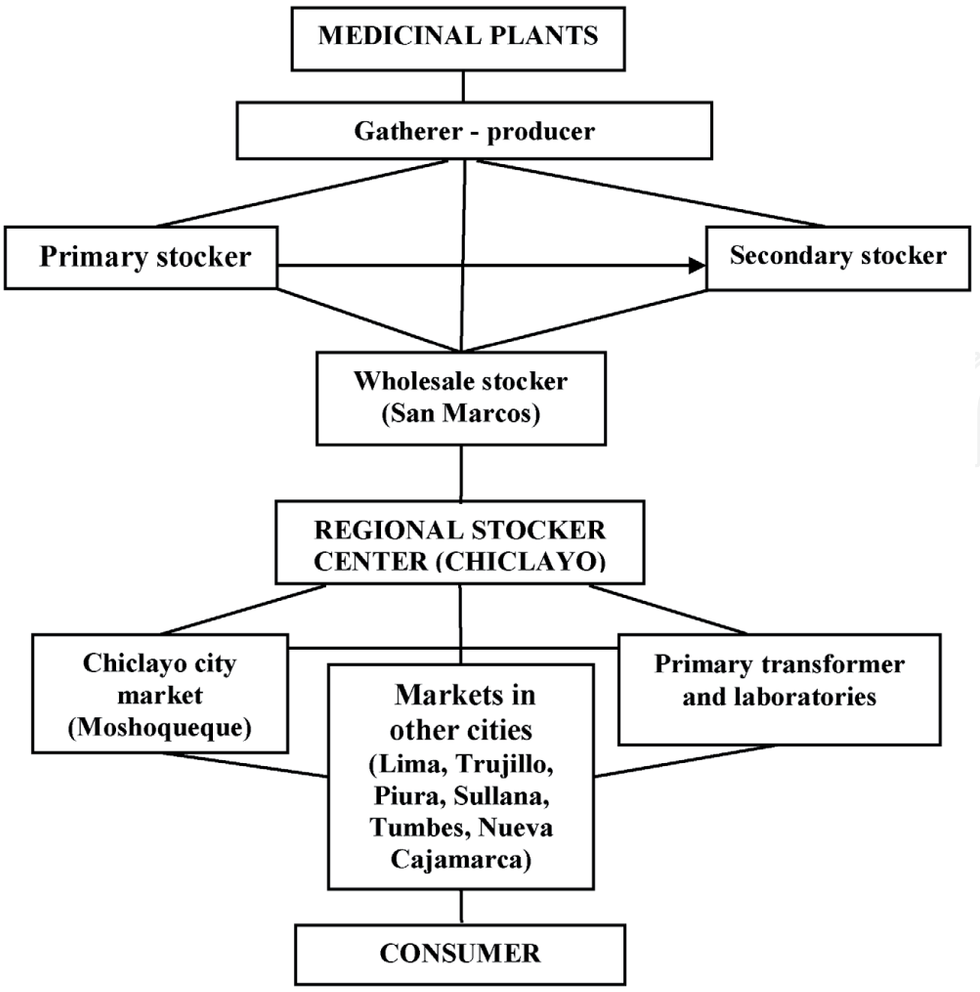


Figure 3.
Diagram of the informal value chain of medicinal plants collected in the city of San Marcos, Cajamarca, Peru.

difference, wild. In 65% of cases the leaf is used. All, except one, come from the Quechua region (**Table 6**). Fifteen of these species are the same as those collected in the city of Cajamarca, but in a fresh state.

5.2.3 Volume and economic value of medicinal plants collected in San Marcos

In the first stage of the study, the total collected volume was calculated by direct observation and the daily purchase records of the four wholesale stockers. In the second stage, we worked with two wholesale stockers and the volume collected by the other two was estimated, based on shipments to the coast. The four stockers compile 510.33 tons / year, of the 37 species. The ten species with the highest collection volumes (t/year) were: pul (83.8), flor blanca (76.9), purenrosa (62.5), lanche (42.8), pie de perro (39.5), chancua (39.0), romero blanco (35.7), zarcilleja (15.0), ishpingo (14.2) y chilca (12.4). However, the species with the best market prices (S./kg) were té de indio (12.6), flor blanca (6.4), pul (3.0), pie de perro (2.0), rumilanche (1.6), escoba amarga (1.6), lanche (1.5) y; chancua, chilca y purenrosa (1.4). Price distortions were also presented, for example, in February - 2018, the price paid to the gatherer of pie de perro rose from 2 to 12 soles/kg, due to the demand for a company of Lima.

The volumes of medicinal plants collected in San Marcos (510.33 t/year), at the gatherer - producer level, mean 724672.86 soles (US $. 207642.65), if sold to a primary stocker and 882876.09 soles (US $. 252973.09), if sold directly to the wholesale stocker of San Marcos. On the other hand, at the level of the wholesale stocker

Species	Vulgar name	Family	Origin	Biological state	Part used	Region
Alnus acuminata kunth	Aliso	Betulaceae	N	C	Leaf	Q
Chuquiraga weberbaueri Tovar	Amaro o Amarro	Asteraceae	N	S	Leaf	Q
Tagetes filifolia Lag*	Anís	Asteraceae	I	S	Foliage	Q
Equisetum giganteum L.*	Cola de caballo	Equisoceae	N	S	Leaf	Q
Otholobium glandulosum (L.) JW Grimes*	Culén	Fabaceae	N	S	Leaf	Q
Minthostachys mollis (Benth.) Griseb.*	Chancua	Lamiaceae	N	S	Leaf	Q
Aristeguietia discolor (DC.) R. M. King & H.Rob	Chilca, Chilca negra	Asteraceae	N	S	Leaf	Q
Cheilanthes myriophylla Desv	Dominio	A diantaceae	N	S	Leaf	Q
Schkuhria pinnata (Lam.) Kuntze ex Thell	Escoba amarga	Asteraceae	N	S	Foliage	Q
Eucalyptus globulus Labill*	Eucalipto	Myrtaceae	I	C	Leaf	Q
Iresine weberbaueri Suess	Flor blanca	Amaranthaceae	N	S	Flower	Y
Achyrocline alata (Kunth) DC.*	Ishpingo Amarillo	Asteraceae	N	S	Foliage	Q
Gnaphalium dombeyanum DC.*	Ishpingo blanco	Asteraceae	N	S	Plant	Q
Myrcianthes discolor (Kunth) McVaugh	Lanche	Myrtaceae	N	S	Leaf	Q
Morella sp.	Laurel de campo	Myricaceae	N	S	Leaf	Q
Niphidium crassifolium (L.) Lellinger	Lengua del ciervo, calaguala	Polypodiaceae	N	S	Stem	Q
Myrsine sp.	Mangle	Primulaceae	N	S	Leaf	Q
Oreopanax eriocephalus Harms	Maqui maqui	Araliaceae	N	S	Leaf	Q
Piper aduncum L.*	Matico	Piperaceae	N	S	Leaf	Q
Piper barbatum Kunth	Mogo mogo	Piperaceae	N	S	Leaf	Q
Dendrophthora peruviana Kuijt	Muca, popa amarilla	Viscaceae	N	S	Leaf	Q
Juglans neotropica Diels*	Nogal	Juglandaceae	N	C	Leaf	Q

Species	Vulgar name	Family	Origin	Biological state	Part used	Region
Clethra fimbriata Kunth	Olvido	Clethraceae	N	S	Leaf	Q
Clinopodium pulchellum (Kunth) Govaerts*	Panizara	Lamiaceae	N	S	Leaf	Q
Desmodium molliculum (Kunth) DC.*	Pie de perro	Fabaceae	N	S	Foliage	Q
Coreopsis senaria S. F. Blake & Sherff	Pul	Asteraceae	N	S	Leaf	Q
Bejaria resinosa Mutis ex Lf	Purenrosa	Ericaceae	N	S	Flower, leaf	Q
Clinopodium sericeum (C.Presl ex Benth.) Govaerts	Romero blanco	Lamiaceae	N	S	Leaf	Q
Myrcianthes myrsinoides (Kunth) Griffin*	Rumilanche	Myrtaceae	N	S	Leaf	Q
Ephedra americana Humb. & Bonpl. Ex Willd.	Suelda con suelda	Ephedraceae	N	S	Foliage	Q
Clinopodium sp.	Te de indio, romero de jalca	Lamiaceae	N	S	Leaf	Q
Lycopodium clavatum L .	Trencilla	Lycopodiaceae	N	S	Plant	Q
Mauria heterophylla Kunth*	Trinidad, tres hojas	Anacardiaceae	I	S	Leaf	Q
Valeriana pilosa Ruiz & Pav.*	Valeriana	Caprifoliaceae	N	S	Root-rhizome	Q
Culcitium canescens Humb. & Bonpl.*	Vira vira	Asteraceae	N	S	Foliage	Q
Brachyotum radula Triana	Zarcilleja hoja grande	Melastomataceae	I	S	Leaf	Q
Brachyotum quinquenerve (Ruiz & Pav.) Triana	Zarcilleja hoja chica	Melastomataceae	I	S	Leaf	Q

**Also collected as fresh plants in the market town of Cajamarca.*

Table 6.
List of medicinal plants collected in the province of San Marcos (Cajamarca): 2019.

of the Coast (when he sells to the other agents of the chain) means 1388105.76 soles (US $. 397738.04). This implies 33.1% of the value of medicinal plants in the Trujillo and Chiclayo markets [39].

6. The collection of medicinal plants, in Cajamarca, in times of the COVID-19 pandemic

The observation made in the cities of Cajamarca and San Marcos, between June and July 2020, at a time when the pandemic has not ceased, indicated the following: In the city of Cajamarca, the stockpiling for shipments to the coast was paralyzed, but the gatherers worked during the quarantine to supply the city, which increased demand and achieved better prices. The weight of each bundle fell by approximately 50% and the price paid to the gatherer-producer rose from 0.35 to 1.00 soles. Also, the retail sale price rose from 0.5 to 1.50 soles/bundle. The species with the highest demand were eucalipto, matico and cascarilla –leaf-- (*Cinchona* spp.). The latter comes from Jaén (174 km from the city of Cajamarca) and the bundle was sold for 5 soles. Other species with high demand were ortiga, ciprés, manzanilla, romero, kión, limón (*Citrus limon* (L.) Osbeck) and ajo (*Allium sativum* L.). In San Marcos, collection and stockpiling were stopped for 3 months (March–June). For a stocker, this stoppage meant a loss of 40,000 soles (US $ .11641.3), approximately. When stockpiling was restarted, the main demand was for matico, eucalipto y manzanila. The latter species is not normally stockpiled in this market. Prices paid to gatherers rose from 0.95 to 2.6 soles/kg in matico and from 1.04 to 2.17 in eucalipto.

7. Conclusions

Inventories of medicinal plants in the countries of South America are incomplete. Similarly, studies on species that supply markets and their commercialization are incomplete.

The department of Cajamarca (Peru) is an important center for the collection, production, use and commercialization of medicinal plants of pre-Inca origins. Currently, the capital city (Cajamarca) is supplied with 470 medicinal species, most of them wild and native to the Andes. In this city there are various intermediaries in the market for medicinal plants, of which one of the most important is the stocker that supplies the markets of the Coast.

The two informal value chains that are developed in this area make minimal quality control, add little value to the products and the predominant actors are the local and coastal wholesale stockers (Chiclayo and Trujillo). Gatherer-producers are informal, without organization, for whom the sale of medicinal plants is a secondary activity in the generation of economic income. The transformation is a growing area and the transforming companies and formal laboratories face the problem of the adulteration and counterfeiting of their products. The consumer of the cities uses products with little security and guarantee.

Most medicinal plants are collected from the Quechua region, few are cultivated, and the main threat in Cajamarca is mining. Others are agricultural expansion, overgrazing, burning of natural vegetation, and overcollection. In San Marcos, the threats in order of importance are overgrazing, burning of natural vegetation, agricultural expansion, and overharvesting and mining.

The commercial value of the plants collected in Cajamarca (fresh) and in San Marcos (dry) is equivalent to US $ 804,333.64 (67% of the market value of the plants sold in the Trujillo and Chiclayo markets).

In the first 3 months of the COVID-19 pandemic, there were no shipments to the coast, from both markets. Demand increased in the city of Cajamarca, especially for eucalipto, matico y cascarilla. Other species with high demand were ortiga, ciprés, manzanilla, romero, kion, limón y ajo. The weight of bundles fell by 50% and prices rose by more than 200%. In San Marcos, when the stockpile was restarted, the main demand was matico, eucalipto y manzanilla.

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Author details

Juan F. Seminario[1], S. Berardo Escalante[2*], Rosel Orrillo-Mejía[1] and Karina Malca-Quiroz[1]

1 Programa de Raíces y Tubérculos Andinos, Facultad de Ciencias Agrarias (FCA), Universidad Nacional de Cajamarca (UNC), Cajamarca, Perú

2 Laboratorio de Biotecnología Vegetal, FCA-UNC, Cajamarca, Perú

*Address all correspondence to: bescalante@unc.edu.pe

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