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Strategic characterization of the cape gooseberry supply chain

Caracterización estratégica de la cadena de suministro de la uchuva

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Abstract

This study deals with the strategic characterization of the supply chain of cape gooseberry in Colombia, an exotic fruit with high economic potential in both domestic and international markets. Using a methodology proven in other agro-industrial chains, it studies the market and identifies and analyzes the actors, links and functionalities of the chain, providing a detailed diagnosis that facilitates decision-making for the stakeholders involved. The study highlights the importance of the cape gooseberry for its nutritional and therapeutic properties and its ability to generate value through agro-industrial processing. Significant challenges are identified, such as the fragmentation of the production chain, the lack of coordination among actors and the need to standardize logistical processes, which limit competitiveness and long-term sustainability. Finally, strategies are proposed to strengthen the integration of the chain, improve logistics and capitalize on growth opportunities in international markets.

Keywords: Agroindustry; Characterization; Cape Gooseberry; Supply Chain.

Resumen

Este estudio aborda la caracterización estratégica de la cadena de suministro de la uchuva en Colombia, un fruto exótico de alto potencial económico tanto en el mercado nacional como internacional. Utilizando una metodología probada en otras cadenas agroindustriales, se estudia el mercado y se identifican y analizan los agentes, eslabones

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y funcionalidades de la cadena, proporcionando un diagnóstico detallado que facilita la toma de decisiones para los *stakeholders* involucrados. La investigación destaca la importancia de la uchuva por sus propiedades nutricionales y terapéuticas y su capacidad de generar valor a través del procesamiento agroindustrial. Se identifican desafíos significativos, como la fragmentación de la cadena productiva, la falta de coordinación entre actores y la necesidad de estandarización de los procesos logísticos, lo que limita la competitividad y sostenibilidad a largo plazo. Finalmente, se proponen estrategias para fortalecer la integración de la cadena, mejorar la logística, y capitalizar oportunidades de crecimiento en mercados internacionales.

Palabras clave: Agroindustria; Caracterización; Uchuva; Cadena de suministro.

Introduction

Globalization has intensified the need for supply chains (SC) to adapt to a rapidly changing technological and economic environment. Globalization has exacerbated disparities, but also opportunities for technological development between developed and developing nations, which emphasizes the integration of emerging technologies (Dos Santos & Guarnieri, 2021). In this regard, the SC competitiveness paradigm, due to its integrating character, has been adequate to respond to the challenges of globalization, demonstrated by its validity as a competitiveness path since the 1970s. It is not companies that compete today, it is SC that actually does, which implies the need for companies to make the necessary efforts to achieve effective SC. The strategic characterization of supply chains for products of national importance, which hold great potential in foreign markets, is essential to promote competitiveness and guide policy decisions.

SC management has focused on improving competitiveness by optimizing logistics processes, including cost reduction and improved customer service efficiency. The SC approach highlights the importance of holistic management that optimizes the flow of information, financial and material flows throughout its stages (Lambert & Enz, 2016).

The characterization of the SC is fundamental to comprehensively understand how each of its components contributes to a better coordination, which favors the generation of value throughout the process by means of the proper functioning of its material, information and financial flows. The SC characterization makes it possible to identify the links, agents, products and processes and provides an overview of the market; in general, the key elements of competitiveness, ranging from suppliers to customers. In summary, the characterization represents a conceptual basis necessary for the management of the SC to promote its improvement.

Fruits are part of the family basket, because their consumption is essential for human health. Their economic potential is also known, many fruits are of high value for their organoleptic characteristics and their goodness related to the richness of substances that promote the health and welfare of both humans and animals. Fruits are susceptible to processing, which promotes value both at the level of artisanal and industrial processing (Instituto Colombiano Agropecuario - ICA, 2019) and at the place where it is marketed. The cape gooseberry (Physalis peruviana L.), the subject of this research, has established itself as one of the products with the greatest economic potential for Colombia, standing out not only for its exceptional nutritional and therapeutic properties, but also for its versatility in agro-industrial processing, which makes it a highly demanded good in international markets (ICA, 2019). The fruit itself is the second most exported exotic fruit in the country, after the gulupa (Passiflora edulis f. edulis) (Santoro, 2022).

This paper presents a strategic characterization of the cape gooseberry SC with emphasis on the Colombian case, which seeks to overcome an unspoken deficiency in the literature. The paper uses the methodology presented by García et al. (2014), which has been previously used to characterize other agricultural and agro-industrial SC in Colombia, see **Table 1.** The article seeks to facilitate the decision-making processes of stakeholders and promote the coordination of the SC to facilitate its sustainability and economic and social development and reduce the issues of the fruit SC (Tenorio et al., 2021a). This focus aligns with national and departmental strategies, supported by entities like MADR,

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ICA, Procolombia, and the Government of Boyacá, which view the cape gooseberry as a strategic crop for the country's development. Therefore, the characterization of SC for key national products with significant potential in foreign markets is of great relevance for the country.

Literature review

This work seeks to comprehensively estimate the economic potential of the cape gooseberry SC through its strategic characterization. The following table presents a review of the characterization of agricultural and agro-industrial SC.

Table 1. Literature review

Reference / Sector	Methodological Proposal	Conclusion
Carvajal et al. (2019) / Sugarcane Agroindustry.	Addressing a robust decision in sugarcane SC: Introduction of a new agricultural investment project in Colombia.	The results showed clear differences in nutritional and bioactive characteristics of fruits grown in arid environments.
De Freitas et al. (2020) / Macaw Palm Agro-industry	SC of Macaw Palm (Corozo Palm for Colombia): Evaluation of a semi-mechanized fruit harvesting system.	The impact of Life Cycle Analysis associated with the transportation of two avocado SC (short (Spanish) and long (Chilean)) and then distribution to several cities in Europe is analyzed.
García et al. (2013) / Oil Palm Agroindustry	Use the methodology proposed by García et al. (2009): 1. Identify the qualitative and quantitative variables. Identify the decisions taken. 3. To carry out the description of the links.	The technological aspect associated with SC and oil palm production in Colombia, as well as the low operability of extractive plants, and the high costs associated with it, contribute to having higher final costs than the international competition.
García et al. (2014) / Cocoa Agroindustry	Proposes a methodological development of the methodology proposed by García et al. (2014).	The bibliographic review of cocoa processing processes worldwide showed a great similarity in the links with respect to the agro-chain in Colombia; the activities and phases do not differ in the flow of material and information through the SC.
García et al. (2018) / Potato agroindustry.	It uses the methodology proposed by García et al. (2014).	This work identified the product portfolio, sustainability in the market for the companies that make up the Association, segmentation and characterization of suppliers and customers in relation to the mission of the CR Association, the behavior of the market for raw materials was identified among other relevant aspects.
García & Olaya (2006) / Coffee agro-industry	Adaptation of the methodology of (Stone & Wood, 2000). Definition of the agents, the associated product flow and the interactions between them.	This paper presents the economic and social context of the coffee sector and describes the global and Colombian coffee value and supply chains.
Grunert et al. (2005) / Innovation in agro-industrial transformation	Demand-side driven innovation in food systems.	Highlights consumer-driven innovation's role in shaping SC value generation and product adaptation.
Ktenioudaki et al. (2021) / Blueberry Agro-industry	Blueberry SC: Critical steps impacting fruit quality and application of a powered regression tree model to predict weight loss.	This study evaluated the operational performance of a prototype semi-mechanized Macaw palm fruit harvester. The evaluations were based on data related to operational capacity, operational efficiency and fruit damage.
Muñoz et al. (2021) / Agro-industrial of cape gooseberry in arid conditions.	Chemical, Nutritional Characterization and Bioactive Properties of Physalis peruviana (cape gooseberry) Fruits from high altitude areas of the Atacama Desert.	This paper presents a conceptual and methodological framework based on empirical evidence derived from Colombian cape gooseberries vis-à-vis European consumers.
Orjuela et al. (2008) / Agro-industrial of cape gooseberry and tree tomato.	It identifies the distribution channels, the value structure and the utility in the channels, for the agro-industrial SC of cape gooseberry and tree tomato in the province of Sumapaz.	Thanks to the research approach used and the information gathered, in the Sumapaz Province and the Capital District, it was possible to determine the process that adds value to the agricultural SC of cape gooseberry and tree tomato. The deficiencies detected for the SC can be broken down into three categories: food handling, intermediation and transportation.

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Reference / Sector	Methodological Proposal	Conclusion
Pedreschi et al. 2022) / Avocado Agroindustry	Short versus long distance avocado SC: Impact of life cycle assessment associated with transportation.	Blockchain is a registry technology with advantages for information manipulation. It collects and uploads reliable data from the final consumption through technologies related to IoT (Internet of Things).
Rodjanatham & Rabgyal (2020) / Fresh Fruit Agro-industry	Quality assurance of international fruit SC through techno management.	The objective of this work was to investigate, categorize and classify the factors that contribute to food waste throughout the logistics process.
Surucu & Tuna (2021) / Agro-industrial fruits and vegetables	Investigating logistics-related food loss drivers: a study on fresh fruit and vegetable SC.	Collective actions (cooperation, coordination and collaboration), present in the SC of artisanal products, generate positive effects in terms of social gains. The study used the content analysis approach suggested by Bardin (1977).
Trienekens (2011) / Agricultural SC in developing countries	Framework for SC analysis in developing nations; coordination and structure challenges.	Characterizes systemic inefficiencies in SC coordination that affect competitiveness in emerging economies.
Vorst (2000) / Food SC performance	Scenario modeling and operational effectiveness in food SC.	Presents a model for evaluating SC configurations to enhance efficiency and strategic alignment.
Zhang et al. (2022) / Fresh Fruit Agroindustry	Blockchain: a new emerging technology to improve current fresh fruit SC.	A three-axis model was developed consisting of the degree of quality assurance, fruit classes, and the degree of SC collaboration.

The literature review conducted in this paper describes some of the most relevant studies on the characterization of SC and related topics. The review evidences a work that characterizes this SC for the year 2008 in complements the aforementioned work.the Sumapaz Province-Colombia, however, the work differs from the one presented here in that it is not based on a specialized methodology; this work updates and

Methodology

The methodology of García-Cáceres et al. (2014) focuses on characterizing the strategic contexts of SC in both a global and domestic context. The details of the methodology are presented below:

- Step 1. Domestic and global SC production. For the development of this step, secondary sources of information were used, such as the Trade Map of the Food and Agriculture Organization (FAO).
- Step 2. SC structure: actors, structural dimensions and relationships are identified. For the development of this step, information from sources such as: Ministry of Agriculture and Rural Development of Colombia, ICA, DANE, among others, was used.
- Step 3. Description of the SC management processes in the Colombian case. Secondary information provided by sources such as DANE, Colombian Ministry of Agriculture, among others, was used.
- Step 4. SC diagnosis, discussion, and conclusions. This stage is based on the methodology of García et al. (2014), which includes the SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats) as a strategic analysis tool. In this study, this tool was applied conceptually and formalized in a matrix structure.

Methodological Development

The following presents the methodological deployment.

Step 1. National and global production of SC

The sugars in the cape gooseberry include: sucrose, glucose, and fructose. Citric acid is the main acid present in the cape gooseberry, followed by malic, ascorbic, and oxalic acids, which decrease in concentration as the fruit ripens (Fischer et al., 2005). The following table reflects the composition of the fruit, which is considered to strengthen the immune system (Fischer et al., 2000). The medicinal properties link the stem and the root (Marchioretto et al., 2020). The chemical components of the cape gooseberry are presented below (See **Table 2**).

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Table 2. Nutritional composition of the cape gooseberry fruit

Components / 100 g of pulp	Fruit	Components / 100 g of pulp	Fruit
Calories	54	Thiamine (mg)	0,18
Water (g)	79,6	Riboflavin (mg)	0,03
Protein (g)	1,1	Niacin (mg)	1,3
Carbohydrates (g)	13,1	Ascorbic acid (g)	26
Fiber (g)	4,8	Pulp g/ 100 g fruit	70
Ashes (g)	1,0	Shell /100 g fruit	3,5
Calcium (mg)	7,0	Seeds /100 g fruit	26,5
Phosphorus (mg)	38	Thiamine (mg)	0,18
Iron (mg)	1,2	Riboflavin (mg)	0,03
Vitamin A (U.I.)	648		

Source: Adapted from Fischer et al. (2000).

According to the reported information, the cape gooseberry provides vitamins, minerals and phosphorus, alkaloids, flavonoids, and carotenoids with low calcium content (Corpoica, 2002), making this fruit appealing to customers seeking a healthy lifestyle. These vitamins are compounds sensitive to different physicochemical processes, mainly oxidation, aqueous extraction (leaching), and thermal treatment (Fennema, 2000). The skin of the cape gooseberry is thin, shiny, and covered by a calyx, while the fruit itself can vary in color from yellow-orange to yellow-ochre when ripe. In addition to salads, ice creams, and baked goods, one can also enjoy them fresh (Corpoica, 2012).

Global Market

According to the harmonized global trade code for the cape gooseberry, its tariff classification is 0810905000 (Food and Agriculture Organization of the United Nations – FAO, 2021). **Table 3** presents the main producers, Colombia ranked 12th among the top producers out of 148 countries. Under this scenario, low production volumes are still observed; in fact, it is at the production level where these capacities must emerge to meet the demand of a supply chain based on large volumes (Muñoz et al., 2021).

Table 4 presents the main exporters of cape gooseberries in the world, Colombia ranks 9th among 146 countries.

Table 3. Main global producers of cape gooseberry in 2019

Country	Production (t)	Country	Production (t)
India	10.755.000	Myanmar	1.448.652
Hong Kong	3.056.082	Indonesia	1.337.349
China	2.893.765	Nigeria	1.144.551
Vietnam	2.803.489	New Guinea	1.136.054
Pakistan	2.547.440	Thailand	948.785
Iran	1.682.769	Colombia	806.346

Source: Adapted from FAO (2019).

Table 4. Main Exporters of Physalis in the World during 2019

Country	Export value (thousands of USD)	Exported quantity (t)	Country	Export value (thousands of USD)	Exported quantity (t)
Vietnam	1.549.394	846.952	India	117.029	96.013
Thailand	785.921	763.596	Turkey	98.143	155.466
Netherlands	293.639	93.034	Spain	96.150	66.096
China	244.837	120.518	Colombia	80.197	19.539
Hong Kong	121.181	143.393			

Source: Adapted from Trade Map (2019).

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Colombia is a country with an export-oriented vocation for fruit, as evidenced by the export/production rate of 2.42%, surpassed only by China, which, however, is the largest importer of fruit; a condition that contrasts with Colombia's distant position of 98 in this import classification. In contrast, India is a country that focuses its production on the domestic market. **Table 5** present Main importers of golden berries in the world, it can be deduced from the table that large economies are the major importers of fruit, with the Asian continent being the main consumer of fruit.

Regarding the cultivated area, see **Table 6**, which shows a correlation between the harvested area and production. Colombia ranks 15th in this ranking, demonstrating good performance per cultivated area. According to Instituto Colombiano Agropecuario - ICA (2022), Colombia's exports of the fruit reached their highest level in 2021, growing by 7%, from 7,363 t to 7,872 t, with the value of exports increasing by 16%, from USD $32,678,630 in 2020 to USD $37,820,445 in 2021. This makes Colombia the only nation in the world that produces and exports the cape gooseberry, granting it the status of the largest global exporter of this fruit.

National Market

Due to the growing global demand and the favorable price of the fruit in the market, the cultivation of the cape gooseberry has proven to be an important productive option. In South America, Colombia leads in fruit exports. During the period from January 2013 to April 2019, no imports of the cape gooseberry were reported (Ministerio de Agricultura y Desarrollo Rural - MADR, 2019). **Table 7** presents the main export destinations.

About 25 nations around the world purchase cape gooseberries grown in Colombia. Throughout history, the Netherlands, Germany, the USA, the UK, Canada, and Italy have been the most common export destinations for the cape gooseberry (Analdex, 2019). The Netherlands was the first market in 2018, accounting for 57% of total exports (MADR, 2019). Figures provided by DANE indicate

Table 5. Main importers of cape gooseberries in the world during 2019

Country	Imported value (thousands of USD)	Imported quantity (t)	País	Imported value (thousands of USD)	Imported quantity (t)
China	918.792	961.781	Russia	125.187	92.626
Netherland	238.083	78.768	France	99.979	41.498
USA	216.175	222.477	United Arab Emirates	69.898	56.879
Hong Kong	188.759	191.953	UK	66.136	33.085
Saudi Arabia	152.921	231.256	Belgium	65.796	24.927
Indonesia	144.930	77.425	Canada	60.984	25.041
Vietnam	144.791	45.525	Italia	60.121	37.832
Germany	135.036	56.323			

Source: Adapted from Trade Map (2019).

Table 6. Countries with the largest harvested area of cape gooseberry worldwide in 2019

Country	Harvested area (ha)	País	Harvested area (ha)
India	1.181.000	Nigeria	165.516
Hong Kong	811.475	Iran	150.054
China	802.058	Papua New Guinea	132.883
Filipinas	796.983	Indonesia	106.387
Myanmar	409.396	Bangladesh	83.470
Vietnam	246.525	México	80.485
Pakistan	189.746	Colombia	70.300
South Korea	177.893		

Source: Adapted from FAO (2019).

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that exports of cape gooseberry from Colombia totaled USD $23.6 million between January and June 2021, representing an 18% increase compared to the same period in 2020 (Hernández, 2021). **Table 8** presents the harvested area and annual production of cape gooseberry in Colombia (MADR, 2019).

Boyaca is the leading department in the production of cape gooseberries in Colombia. It has 32 plantations registered under the export work plan, totaling 527 ha. 13 of these plantations have been authorized, while the remaining 21 are in the certification process (ICA, 2019). The weather conditions favor the export of cape gooseberry from the department, which does not require cold treatment. These plantations are located in the municipalities of Santa Rosa de Viterbo, Ramiriquí, Viracachá, Gámeza, Úmbita, Arcabuco, Floresta, Tibaná, Soracá, and Ventaquemada (ICA, 2019). The municipalities with the highest number of hectares cultivated with cape gooseberry in 2021 were Ramiriquí, Ventaquemada, Ciénega, and Úmbita (Procolombia, 2022). **Table 9** presents the harvest area and production tons by department.

Table 7. Export destinations for cape gooseberries from Colombia 2019

Country	Exported quantity (t)	País	Exported quantity (t)
Netherlands	5.549,81	Germany	253,38
UK	601,50	Brazil	172,77
USA	585,16	France	106,73
Canada	434,34	Italy	54,76
Belgium	419,91	Spain	47,74

Source: Adapted from Legiscomex (2019).

Table 8. Colombia Harvested Area and Annual Production

Colombia	Harvested area (ha)	Colombia	Annual Production (t)
2015	64.060	2015	722.684
2016	68.224	2016	786.943
2017	61.009	2017	722.895
2018	66.255	2018	729.032
2019	70.300	2019	806.346

Source: Adapted from FAO (2019).

Table 9. Harvest Area and Production Tons by Department in 2019

Department	Harvested area (ha)	Production (t)	Department	Harvested area (ha)	Production (t)
Boyaca	527	7.291	N. Santander	78	766
Cundinamarca	491	5.235	Cauca	57	422
Antioquia	58	1.349	Santander	37	366
Nariño	146	949			

Source: Adapted from MADR (2019).

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Table 10 presents the harvest area and production of the Boyaca department during the period from 2016 to 2019, which showed continuous growth.

Table 10. Harvest Area and Production Tons in Boyaca

Boyaca	Harvested area (ha)	Production (t)
2016	357	6.115
2017	492	7.977
2018	496	7.172
2019	527	7.291

Source: Adapted from MADR (2019).

The importance of fruit cultivation for the development of the Boyaca department was considered in the development plan, which proposes its expansion by 100 new ha and the strengthening of its production chain with measures such as the creation of collection centers in producing regions, the development of productive partnerships, and the improvement of input supply (Gobernación de Boyaca - Secretaría de Agricultura, 2017). According to the most recent statistics released by DANE, exports of cape gooseberries reached USD $6.5 million between January and February 2022. In the next five years, it is expected that the fruit will generate over USD $100 million in export revenues. In this regard, the government of Boyaca continues to encourage local farmers to cultivate through additional strategies such as providing education on better agricultural techniques and promoting international certification of good agricultural practices (GAP) that favor entry into and maintenance of international markets (Procolombia, 2022).

Step 2. Structure of the SC: actors, structural dimensions, and relationships

The SC of the cape gooseberry, represented in **Figure 1**, consists of several stages that range from activities related to the initial preparation of the soil to the stage of marketing the fruit to the final customer.

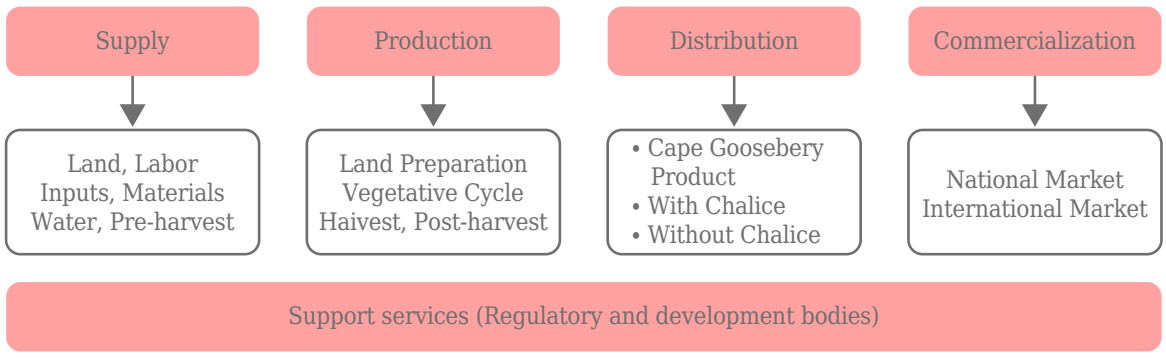
The cape gooseberry is a vigorous, herbaceous plant that grows in the form of a highly branched shrub. Due to its imprecise extension, throughout the cycle, the apical meristem maintains its vegetative state (Fischer et al., 2005). The cape gooseberry quickly adapts to different agricultural and ecological environments (Fischer et al., 2000). In Colombia, the most productive crops are found at altitudes between 1,800 and 2,800 meters above sea level, in temperatures ranging from 13 to 18 °C, and with annual precipitation between 1,000 and 2,000 mm. The average annual temperature for the crop is between 17-19 °C, with an average annual rainfall of 1,216 mm. These conditions explain why Boyaca is an ideal territory for its cultivation (IDEAM, 2021).

When they are fully ripe, the cape gooseberries have a specific gravity that ranges from 14.7 to 25°Brix. Crops grown at high altitudes above sea level have lower sugar content in their composition (Fischer et al., 2000).

Provisioning

It is recommended to create seedbeds or nurseries (Gobernación de Antioquia- Secretaría de Agricultura, 2014), starting from

Figure 1. Characterization of the Supply Chain of the cape gooseberry in Colombia.



Source: Adapted from MADR (2019).

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the acquisition and care and improvement of seeds, the procedure is as follows:

- Obtain the seed supply from a commercial supplier registered with the ICA.
- For optimal germination and growth of the seedlings, the substrates must be properly prepared and sterilized. The substrate, being an inert substance free of pests, has shown optimal seed germination rates, making it the most recommended medium for growing cape gooseberries. It is also possible to use a prepared substrate, combining soil (two parts), sand (one part), and composted or deeply decomposed organic matter (one part). To avoid phytosanitary problems, this combination must be disinfected (Corpoica, 2002).
- Solarization is recommended, which is a physical treatment that directly utilizes the sun's energy to decontaminate the substrate. The procedure involves using polyethylene with a thickness of six mils to hermetically seal the wet substrate, which is then placed in beds with a maximum height of twenty centimeters. This causes the death of any harmful organisms that may have been present in the substrate, and finally, the polyethylene is removed. It is recommended to apply doses of 1 g of Trichoderma sp. Solarization can take between 30 and 45 days to complete, depending on weather conditions.

Production

Most cape gooseberry producers operate on a small scale, employing a significant amount of labor in the harvesting and post-harvesting processes (MADR, 2019). The productive phase begins with planting and continues until the end of the crop's useful life, including the harvesting cycle. In the more productive municipalities of Boyaca this phase lasts between 300 and 450 days, while in the better regions of Cundinamarca the duration of the process can extend up to 540 days (Departamento Administrativo Nacional de Estadística - DANE, 2018).

The phenological cycle of the plant has an unpredictable growth pattern, as flowering occurs simultaneously with the development of leaves, branches, and roots, as well as reproductive growth, including flowers and fruits; this prevents the plant from entering a period of dormancy. The new fruit takes between five and seven days to insert itself into the next node of the same branch. The first 10 days of fruit growth are characterized by a period of rapid expansion, both in size and weight (Gobernación de Antioquia- Secretaría de Agricultura, 2014).

Planting begins with the purchase or production by the producer of young plants of about 90 days. The planting densities will range between 1,111 and 1,660 plants per ha, a quantity that has allowed for the effective execution of cultivation activities (Departamento Administrativo Nacional de Estadística DANE-SIPSA, 2016). The use of trellising is necessary for this crop because the plant has an herbaceous nature, which prevents it from coming into contact with the soil, thereby reducing the risk of contamination. Most of the time, the method is used in "T" or "V," with the placement of posts in each furrow to insert the wires that support the branches of the plant.

There are two clearly defined harvest seasons that take place in the first year of production. The collection takes place once or twice a week, depending on the volume. Yields begin to decline starting from the second year of cultivation, at which point a noticeable decrease in fruit size is also observed. After harvesting, sanitation pruning is carried out, followed by formative pruning (after 100 or 120 days) and renewal pruning, which are performed after each peak of production (Fischer et al., 2000).

When grown under ideal conditions, the complete cultivation of the cape gooseberry goes through a growth phase that lasts between 17 and 27 months, consisting of the following stages (Fischer et al., 2000), which are described in **Figure 2.**

The moment when the calyx turns yellow, which happens at the same time as the fruit, is when most growers consider it the optimal time to harvest. The collection takes place two to three times a week. The peduncle is cut with scissors about two centimeters from the branch that holds the fruit; this is done

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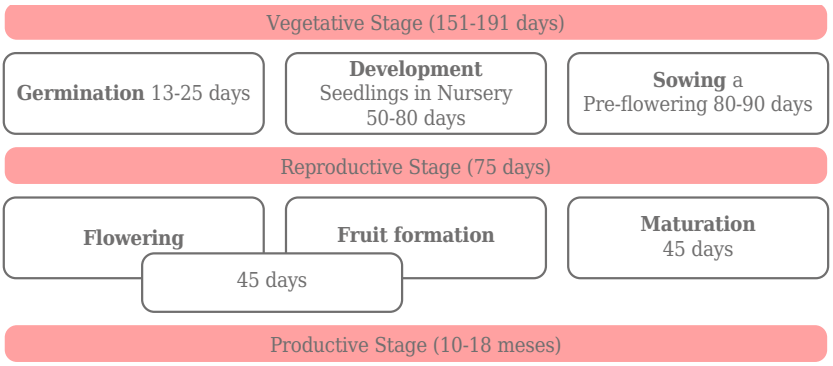
so that the capacho is not lost, which keeps the fruit fresh for a longer time. The harvest concludes with its storage in plastic baskets (DANE-SIPSA, 2016).

Under the title "Good Agricultural Practices - GAP" the Secretariat of Agriculture and Rural Development of the Antioquia Government (2014) developed a Technical Manual for the cultivation of cape gooseberry (Gobernación de Antioquia- Secretaría de Agricultura, 2014), aimed at providing farmers and technicians with a technological tool for its production (Norm 5400/05 and Resolution 4174/09). The goal is to increase the productivity and competitiveness of the crop in the long term and to establish a more effective production process. The guide also seeks sustainable development where agriculture and soil management promote the preservation and recovery of fertility, organic matter content, biological activity, and the structural composition of soils.

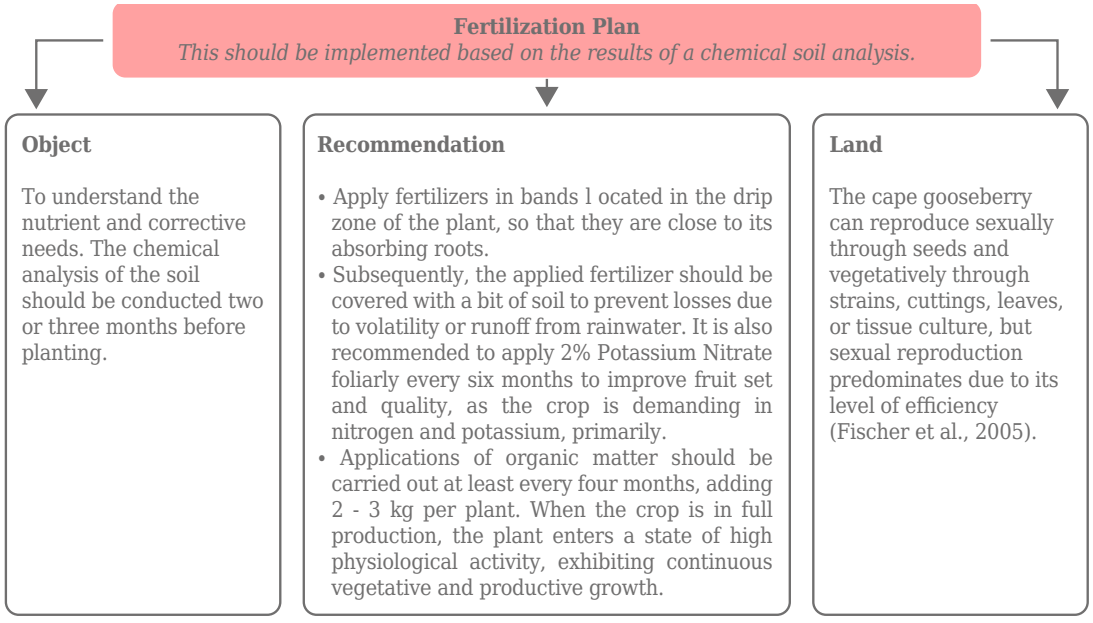
Cultivation requires that the soil be prepared well in advance of planting and should be done with minimal tillage to reduce soil waste. **Figure 3** presents the fertilization plan required by the crop.

Figure 2. Stages of production of the cape gooseberry.



Source: Prepared based on Fischer et al., (2000) (Cited by Gobernación de Antioquia - Secretaría de Agricultura, 2014).

Figure 3. Fertilization plan.



Source: Adapted from Corpoica (2002).

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Distribution

According to the "Information System for Prices and Supply in the Agricultural Sector,"(SIPSA), the pre-selection of the fruit is carried out by the producer on their farm based on volume, degree of ripeness, and the overall health condition of the fruit. Even in export trading companies, the classification of fruit is done considering criteria such as: good appearance, free from pests, diseases, or skin breaks, in order to meet demand requirements and logistical considerations such as packaging so that the product can be stored in 1-kg cardboard boxes used in the international market. In contrast, in the domestic market, it is common to use polyethylene baskets with a smooth bottom that weigh between 250 and 450 g (DANE-SIPSA, 2016).

In the post-harvest facility, a maximum of two days is usually spent on sorting the fruits before they are placed in containers and sent to the port. The trip to Santa Marta or Cartagena can take up to three days, while traveling to Europe can take an average of 18 to 20 days (Agronegocios, 2017). **Figure 4** illustrates the distribution channel (DANE-SIPSA, 2016).

According to the Technical Manual on Physalis (Gobernación de Antioquia- Secretaría de Agricultura, 2014), there are logistical deficiencies at the national level that prevent harvesting from being carried out under GAP standards. The result is losses estimated at up to 30% of production, which greatly harms the profitability of agricultural companies.

Commercialization

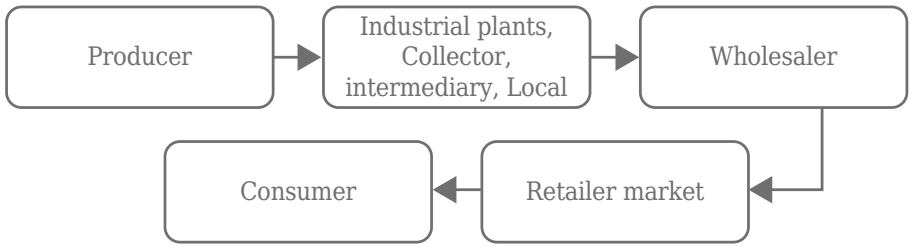
The fruit sold in the producing regions for the domestic market is purchased by traders who consolidate it and sell it retail or wholesale in other cities across the country. Although a good amount of the fruit is distributed with the *capacho*, there is a growing market for those who wish to acquire it without this chalice. Due to the fragility of the cape gooseberry, special care must be taken in packaging and transportation in order to preserve its integrity under optimal conditions until its final destination (DANE-SIPSA, 2016). Transport usually covers multi-channel routes that require controlled refrigeration due to the perishable nature of the fruit, so it is recommended to keep the *capacho* when the preservation time requires it. **Table 11** presents the costs of the SC for 2019 for national production.

Table 11. Establishment, maintenance, and harvest costs of the cape gooseberry in 2019

Costs	($/ha)
Adaptation	220.000
Preparation and sowing	525.000
Tutoring	2.308.000
Supplies	5.206.561
Maintenance	4.641.667
Harvest	5.625.000
Other indirect costs	2.098.000
Total	20.624.228

Source: Adapted from MADR (2019).

Figure 4. Distribution Channels



Source: Own elaboration based on (DANE-SIPSA, 2016).

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The nature of the agricultural business is prone to frequent cases where the price obtained for the product throughout the marketing process does not profitably compensate for the production costs and the risks incurred. The phases of planting, maintenance, and harvesting of the cape gooseberry crop involve a significant amount of labor, which accounts for more than 50% of the total costs during the two-year production cycle of the crop. The costs of agrochemical inputs represent approximately 25% of total expenses (MADR, 2019). In order to reduce the risks of agricultural activity, stakeholders in the SC need to access resources for research in the sector from the Horticultural Promotion Fund, which materializes in technical assistance and technology transfer.

Step 3. Description of the management processes of the SC for the Colombian case

"Corabastos" in Bogota is the main delivery hub for cape gooseberry; between January 2015 and April 2016, it sold 963.41 t, which is equivalent to 65.4% of the national total of 1,473 t (DANE-SIPSA, 2016), see **Table 12**.

Table 12. National Markets 2016

Market	Ton.	Participation (%)
Bogota DC, Corabastos	963,41	65,4
Medellín, Central de Mayoristas de Antioquia	246,95	16,76
Cúcuta, Cenabastos	140,23	9,52
Medellín, Plaza Minorista	56,85	3,86
Bucaramanga, Centroabastos	48,71	3,31
Other markets	16,9	1,15
Total	1.473,05	100

The department of Cundinamarca supplies 38.4% of the cape gooseberry sold in the Corabastos market. These supplies of cape gooseberries come from 17 different municipalities, including Granada, Silvania, San Bernardo, Fusagasugá, Cabrera, and Choachí. Another important supplier is Nariño, which contributes 12.56 % of the total and sources from municipalities such as Ipiales, Puerres, and Pupiales. Boyaca is also a supplier for the wholesale market, with its 15 municipalities producing fruit contributing 11.56%, particularly highlighting Sutamarchán, Tibaná, Buenavista, and Ramiriquí. Providers from departments such as Risaralda, Valle del Cauca, and Huila also participate, but to a lesser extent (DANE-SIPSA, 2016).

Regarding other wholesale centers, the "Central de Mayoristas de Antioquia" sources cape gooseberries from 14 municipalities in the department, mainly from La Unión and Guarne. Cenabastos, located in Cúcuta, is supplied by various areas of the Norte de Santander department, including Cácota and Chitagá.

It is important to note that 67.93% of the fruit is transported in turbo vehicles, followed by 600-trucks (15.61%) and 350-trucks (11.18%); the remaining 5.28% is distributed among tractor-trucks, 100 and 150 vans, and double-trucks, among others (DANE-SIPSA, 2016). Although it is common for trucks used to transport cape gooseberry to be used exclusively for this commodity, it is not unusual for transporters to group other agricultural commodities to fill the load, usually bell pepper, tomato, and gulupa.

Step 4. Diagnosis and discussion of the SC

According to a study conducted by the National Association of Foreign Trade (Analdex, 2018), 65.6% of the production of cape gooseberry is destined for the local market and for industrial applications in the international market, while the remaining 34.4% is used as fruit for the international market. The production of high-quality cape gooseberries, determined by size and color, is exported, while the remaining part of the harvest is allocated to the processing industry or the local fresh fruit market (Tenorio et al., 2021a).

The cultivation highlights a problem of domestic demand for the crop, due to low consumption, which opens up an opportunity to promote the fruit and foster a culture of consumption (MADR, 2019). Over the last half century, the average per capita fruit consumption rate has increased from 36% to 40% worldwide; however, in Colombia, 35% of the population has not consumed fruit.

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In Colombia, the products that generate the most losses and waste are fruits and vegetables; with the cape gooseberry being the fourth fruit on the list, with 4,832 tons per year in losses (Universidad Nacional de Colombia - UNAL, 2021). The lack of technology and infrastructure, the limited knowledge base, losses, and waste are systemic throughout the food supply chain, from post-harvest to retail. The FAO (2021) states that losses are primarily due to the poor functioning of the supply chain, which includes aspects such as: limited technical capacity, inadequate production and handling methods, insufficient infrastructure, and deficiencies in the institutional and legal framework. Due to the commercial quality requirements. In the retail offering phase, they emphasize the aesthetics of the product; fruits that do not look their best are rejected, even if they are healthy and suitable for consumption in terms of nutrition and safety, which contributes to food waste, with the cape gooseberry being no exception.

The cape gooseberry in Colombia is currently facing challenges in its internationalization. Despite being marketed in European markets for about two decades, it is still not visible in international trade statistics due to low trading volumes (FAO, 2019). The statistics on production and trade from the last 5 years show that the attempt to scale has been unsuccessful because consumers seem to be unaware of the quality attributes of the fruit (Tenorio et al., 2021a).

Tenorio et al. (2021b) highlight that greater standardization and coordination within the supply chain could not only improve operational efficiency but also open new opportunities in international markets. Diaz (2024) emphasizes the importance of technological integration and sustainability as pillars for the competitive development of the SC in agricultural products, which is vital for Colombian cape gooseberry to continue gaining ground in demanding markets.

As part of the strategic diagnosis of the SC, a SWOT analysis was conducted to guide the formulation of recommendations. The analysis highlights favorable climatic conditions, global market leadership, and product versatility as key strengths. However, the supply chain suffers from fragmentation and underdeveloped infrastructure. Growing international interest in exotic, healthy foods represent a major opportunity, while compliance with strict phytosanitary regulations and climate-related risks remain significant threats (See **Table 13**).

Table 13. SWOT Matrix of the Colombian Cape Gooseberry Supply Chain

Opportunities	**Threats**
Increased valuation of healthy and functional foods in global markets.	Stricter phytosanitary and certification requirements in foreign markets.
Potential integration in value-added product chains (e.g., jams, preserves).	Price volatility and rising competition from emerging producers.
Access to government support programs and export initiatives.	Climate variability affecting yield and fruit quality.
Strengthening of farmer associations and certification access (GAP, GlobalG.A.P).	Aesthetic preferences in export markets leading to rejection of visually imperfect fruit.
Strengths	**Weaknesses**
Favorable climatic and soil conditions for cultivation.	Significant fragmentation of the supply chain.
Status as the world's largest exporter of cape gooseberry, with a solid reputation for quality.	Lack of coordination among the different actors in the chain.
High economic potential due to the fruit's exceptional nutritional and therapeutic properties.	Underdeveloped infrastructure, which creates a competitive lag.
Product versatility for use in various industries, including food, gastronomy, and medicine.	High post-harvest losses, estimated at up to 30% of production.
High-yield crop due to its endemic nature and adaptation to local conditions.	High production costs, with labor accounting for over 50% of the total.
	Low domestic consumption and demand for the fruit.
	A lack of state and private funding for research on exotic fruits.

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Conclusions

The supply chain shows a traditional structure of an agricultural supply chain, which includes six main stages, involving input suppliers, small and medium farmers, local and international traders, the food industry, and domestic and foreign end consumers.

The Colombian cape gooseberry has a remarkable potential for expansion in national and international markets, thanks to its outstanding nutritional and organoleptic properties, as well as its versatility for use in various industries, such as food, gastronomy, delicatessen products, and medicine. Furthermore, it is a high-yield crop in the country due to the competitive advantages based on climatic and soil conditions, as well as the crop's adaptation stemming from its endemic nature, which facilitates sustainable production. The crop also enjoys a solid reputation, which reinforces Colombia's image as a reliable producer of quality fruits. An analysis allows us to conclude that exports reflect the high value of the sector, even though the cultivated area is not representative on a national scale. This highlights an incentive for the development of cultivation and entry into new markets, such as countries like Mexico or Chile and the Asian countries.

Despite the competitive advantages, the cultivation is partly limited by the fragmentation of the SC; consequently, there is a clear need to promote a trade organization for the cape gooseberry. Despite the effort to promote union organization, it is still in an initial phase in terms of development. Another of the evident problems is the infrastructure, which, despite having improved in recent decades, still shows a competitive lag compared to other countries in Latin America. In a related manner, the adoption of quality control systems and the efficient management of the cold chain are particularly important for maintaining the freshness and quality of the cape gooseberry during its export.

There is also a lack of research and studies on the cultivation of exotic fruits, due to the lack of state and private funding. In this regard, and as an example, the development of sustainable production models and the implementation of advanced agricultural practices are essential to ensure long-term competitiveness. Specifically, to materialize the vision of the cape gooseberry as a strategic crop, it is essential to strengthen support for farmers in terms of technical assistance, training, certifications in GAP, ICA registration for exporting farms, Global Gap, organizational and commercial reinforcement, research and development, and the additional objectives of the agricultural promotion fund, as well as to facilitate their access to investment capital. This will allow them to meet international standards and fully take advantage of expansion opportunities in the global market.

Conflict of interest

No potential conflict of interest was reported by the authors.

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