Analysis of a lime agri-food chain

Análisis de una cadena agroalimentaria de limón

Authors

✉ ¹*Javier Gregorio García Arteaga* iD

✉ ²*Neyfe Sablón Cossío* iD

✉ ²*Sebastiana Monserrate Ruiz Cedeño* iD

¹Maestría con Trayectoria Profesional en Gestión de Proyecto. Instituto de Posgrado. Universidad Técnica de Manabí, Ecuador.
²Instituto de Posgrado. Grupo de Producción y Servicios. Universidad Técnica de Manabí. Ecuador.
³Facultad de Ciencias Administrativas y Económicas. Grupo de Producción y Servicios. Universidad Técnica de Manabí, Ecuador.
*Correspondance author.

Abstract

Lemon cultivation is an important activity in the Ecuadorian diet. Therefore, the objective of this research was to analyze the lime agri-food chain in Manabi, and specifically the actors of the Riochico parish. The methodological approach that was applied in the investigation is quantitative, an integration checklist was applied and the level of integration in the chain was calculated. The checklist presents 13 variables and 121 items. The results show that the chain presents a low level of integration, and is in the negotiation stage. A strategy and three objectives were identified for the improvement of the lemon agri-food chain. This study has practical value.

Keywords: productive chain; relations; agricultural product; evaluation; supply chain.

Resumen

El cultivo de limón es una actividad importante en la alimentación ecuatoriana. Por ello, el objetivo de la investigación fue analizar la cadena agroalimentaria del limón en Manabí, y en específico los actores de la parroquia Riochico. El enfoque metodológico que se aplicó en la investigación fue cuantitativo, se aplicó una lista de chequeo de integración y se calculó el nivel de integración en la cadena. La lista de chequeo presentó 13 variables y 121 ítems. Los resultados mostraron que la cadena presentó un bajo nivel de integración, y se encuentra en la etapa de negociación. Se identificó una estrategia y tres objetivos para la mejora de la cadena agroalimentaria del limón. Este estudio presenta un valor práctico.

Palabras clave: cadena productiva; relaciones; producto agrícola; evaluación; cadena de suministro.

Introduction

Agro-chains are based on collective and consensual action between its participants, in order to satisfy a specific demand. These constitute social improvement through increasing income, creating jobs and developing the territory (Anaya, 2015). The progressive growth in a value chain shows that it is economically sustainable, as it expands into the market.

In Ecuador, lime is produced for local consumption and export. In 2021, there were 3,846 production units for these two purposes. The province of Manabi is one of the main agricultural zones of production. It has an area of 19,878 km² and a population of 1,369,780. The capital, Portoviejo, has a remarkable availability of productive resources, in short and constant cycles. Lime is a flagship product in Portoviejo, with 1,200 ha of land dedicated to its cultivation; it has also been, for many years, the main source of income for families in Manabi (Valarezo, 2021).

One of the most prominent issues with the commercial activity between agricultural producers and the general population, is that collection centers are not always attractive to private producers (Rizo et al., 2017). Within the studied territory, there are collection centers where local producers can only achieve minimal profits. According to Abadia et al. (2020), there are two key aspects related to the capability of collection centers to increase the annual quantity they recieve: reception capacity and rotation index. Collection centers allow gathering a variety of agricultural products. This, with the goal of standardizing the quality and achieving a stable pression in commerce (Bazurto, 2022).

This is the context for the research. The objective was to analyze the lime agro-chain in Manabi, specifically the producers in the Riochico parish. The study will serve as a preliminary study for further research.

Materials and methods

The present research used a quantitative and descriptive approach. The agri-food chain was mapped in a encompassing manner, with its actors and links. For the chain analysis, the integration check-list of Sablón-Cossío et al. (2021). This tool has 13 variables and 121 items (table 1).

Table 1. Items of the integration check-list.

Items	Characteristics
Business strategy	23
Strategic objectives	6
Formulation of scenarios in the organization	9
Contracts	4
Information	10
Plans	6
Demand forecast	10
Purchases	13
Stock management	14
Providers	5
Goods distribution	17
Performance indicators for evaluation	4
Clients	5
TOTAL	121

Source: Sablón-Cossío et al. (2021).

The Likert scale from 1 to 5 was used for the items measured on an ordinal scale, where the value 1 was related to the criteria "very low"and 5 "very high". On the other hand, the ordinal variables En,m and CDn were calculated for each of the businesses. Subsequently, the level of integration of the chain was checked using the following equation:

$$NI_{cs} = \sum_{n=1}^{7} P_n * Mo_n$$

Where:

NIcs: chain integration level.

Pn: specific weight of importance given by experts for dimension n.

Mon: mode calculated for each En, m and for each CDn.

If the result achieved in NIcs was greater than zero and less than or equal to one, "Very low level"; greater than one and less than or equal to two, "Low level"; greater than two and less than or equal to three, "Average level", greater than three and less than or equal to four, "High level" and greater than four and less than or equal to five, "Very high level" (Sablón-Cossío et al., 2021).

These five states of NIcs help to know that, if the dimensions were evaluated correctly, it was because the NIcs reached an adequate level. Defining the level of integration depended on the actor with the lowest NPC value in the chain. This happens as long as the actor has a direct relation with the end product or service of the chain.

The last part of the research was focused on identifying the strategies and objectives that must be considered in the chain based on the NICS calculation (table 2). For this reason, the matrix for selecting integration strategies in the supply chains was managed following (Sablón-Cossío et al., 2017).

Table 2. Types of strategies for chain integration.

Integration leveles	Allotment I	Negotiation II	Association III	Cooperation IV	Coordination V	Colaboration VI
NPC	$1 < NPC <= 2$	$1 < NPC <= 2$	$2 < NPC <= 3$	$3 < NPC <= 4$	$3 < NPC <= 4$	$4 < NPC <= 5$
Types of strategies	Resource allotment	Discussion focused on leadership in costs, differentiation, focus or niche	They join goods in critical processes for only economic purposes or other interests	Long-term contracts	Connection via TIC	Integration into the supply chain
		Relation as competitors		Few providers	Share information	Joint planning
						Share technologies

Fuente: Sablón-Cossío et al. (2017).

Results and discussion

Lime as a consumer product

Citric fruits have many features that are attractive to the consumer, specially the color and taste of its pulp (meso-endocarp). They are also non-climacteric fruits, with relatively low respiration rates and ethylene production, and they show major changes in composition and texture after being harvested (Cocco, 2016).

The minimum process for cirtric fruits consists of: washing, prepartion (peeling), disinfection, segmentation, packaging, and refrigeration, for then to be sold to the consumer in appropiate conditions (Cocco, 2016). The variables that influence fruit quality are: biomass, equatorial and polar diameter, peel thickness, biomass and juice percentage, acidity, solluble solids, and Vitamin C content (Santistevan et al., 2017).

In 2013, citrics were cultivated on 8,3 milllions hectares worldwide, yielding 123,8 millions tons (Guanoluisa, 2018). This corresponds to 58% oranges, 23% mandarins, 12% limes (including lemons) and 7% grapefruits. China and Brazil produce 42%, followed by the United States with 8.5% and Mexico with 4.9%, respectively. (Organización de las Naciones Unidas para la Alimentación y la Agricultura (FAO), 2020).

Between 2000 and 2014, Mexico was the second largest lime producer with 1,93 million tons of production(Nicolás y Favila, 2019), surpassed by India, China and Argentina. In terms of exports, FAO (2020) indicated that Mexico reached the second postion in the world with an average prodiction of 413 million tons, surpassed by Spain (413 million tons), and followed by Turkey (302 mill tons) and Argentina (295 mill tons).

In Mexico, production and commerce of citrics are very important, both for the internal market and export. Mexico was the fifth largest lime producer in 2013, surpassed only by China, Brazil, United States and India (Valencia y Duana, 2020).

In 2020, India became the largest lime producer in the world, yielding a volume of approximately 4 million metric tons (Guanoluisa, 2018). Meanwhile, Mexico and China were in the second and third position, respectively. World lime production suffers from constant fluctuations every year with no clear trend, although there has been a constant decrease in the last two years. In 2020, the global production volume was 8,4 million, a decrease of

almost 500,000 tons compared to 2018, the year with the highest yield of the decade. Around 20% of said quantity was produced by countries in the European Union, where there was an increase of 200,000 tons compared to 2019 (Orús, 2022).

Description of the lime agro-chain in Manabi

In Ecuador, the Nationl Insititue of Statistics and Census (INEC, 2019) there are 6,308 ha of cultivated land, of which 4,673 yield 28,881 tons. According to the Agricultural Census of 2019, with a sample size of 5,731 segments and 3,678 agricultural unit production (UPAS) of lime; 9,152 ha qere cultivated and 5,487 were harvested; the production was concentrated in the coastal region, mainly in the provinces of Manabí and Guayas.

The province of Manabi is one of the areas with the highest lime production of the country, with 1,200 ha (table 3) concentrated around the Portoviejo river valley, in the municipalities of Santa Ana, Rocafuerte and Portoviejo. In the city of Portoviejo, the zone with the highest lime production is the Riochico parish. Portoviejo, Santa Ana, Rocafuerte and Chone are where the majority of lime is produced. The rural parish of Riochico has the most hectares for lime cultivation, followed by Calderón, Chirijos, San Plácido and Alajuela.

According to MAG, in Manabi there are 3,157 ha of lime cultivation, of which 300 are found in the Riochico parish. This represents a weekly yield of 2,000 and 2,500 of 38 kg sacks. The product is sold to wholesale markets in Quito, Guayaquil and Ambato, through middle-men. In Manabi, and specially in Riochico, production is almost entirely for the internal market. High standards and quality assurance that the product has to go through limits its acces to foreign market.

Vásquez y Quiroz (2019) analyze lime production in relation with the profits in a parish of Mnabí. They estimated the cost of lime harvesting is between $1,000 and $2,000 USD per ha^{-1}.

Table 3. Distribution of lime cultivation by municipality, in the Manabi Province.

Municipality	Area (ha)	Cultivated areas in Manabi (%)
Portoviejo	605	19.16
Manta	20	0.63
Montecristi	40	1.26
El Carmen	125	3.95
Jipijapa	180	5.70
Pedernales	80	2.53
Bahía	137	4.34
San Vicente	50	1.58
Jama	108	3.42
Flavio Alfaro	120	3.80
Tosagua	80	2.53
Rocafuerte	310	9.81
Calceta	180	5.70
Santa Ana	380	12.18
24 de Mayo	102	3.23
Olmedo	50	1.58
Jaramijó	0	0
Pajan	60	1.90
Puerto López	70	2.21
Pichincha	120	3.80
Junín	90	2.85
Chone	250	7.84
Total	3.157	100

Data obtained from the MAG geo portal.
Source: Ministry of Agriculture of Livestock (MAG, 2019).

Some key factors that determine profit are lack of organization and not having a collection center, so producers have to sell their products to low prices. The profitability was $500 USD for each harvest in a year (3 to 4 months), with 200 to 300 packs (800 to 1000 lime units), with a value of $20 to $45 USD (depending on the season); these financial resources were used for food, education, basic services and medicine, leaving little left to mantain the land, therefore not being able to invest in production.

The creation of new projects and the diversification of lime varieties may be good bussiness ideas to break into new markes, and allowing their productive units to grow and become competitive (table 4).

Table 4. Lime prices per month between 2020 and 2021.

	Year 2020	Year 2021	Year 2022
Month	Average price	Average price	Average price
January	15	8	22
February	15	10	15
March	16	7	12
April	35	12	-
May	40	13	-
June	55	18	-
July	0	0	-
August	0	0	-
September	15	20	-
October	16	25	-
November	16	15	-
December	15	22	-

Description of the agro-chain of the research

The lime agro-chain, the object of study, is composed of three links: resource suppliers, primary lime producers, collection centers, transformers, commerce, direct sale and consumers (figura 1).

The resource suppliers are the first link in the chain. They provide agricultural resources such as : foliar fertilizers, fungicides, insecticides, pumps, pruning shears, and other resources necessary for planting, cultivation, maintenance and maximization of yield in lime plantations. The main agricultural warehouses where producers buy resources are: Agripac, Agroquímica, La Finca, Almacén I, and Comercial El Agro.
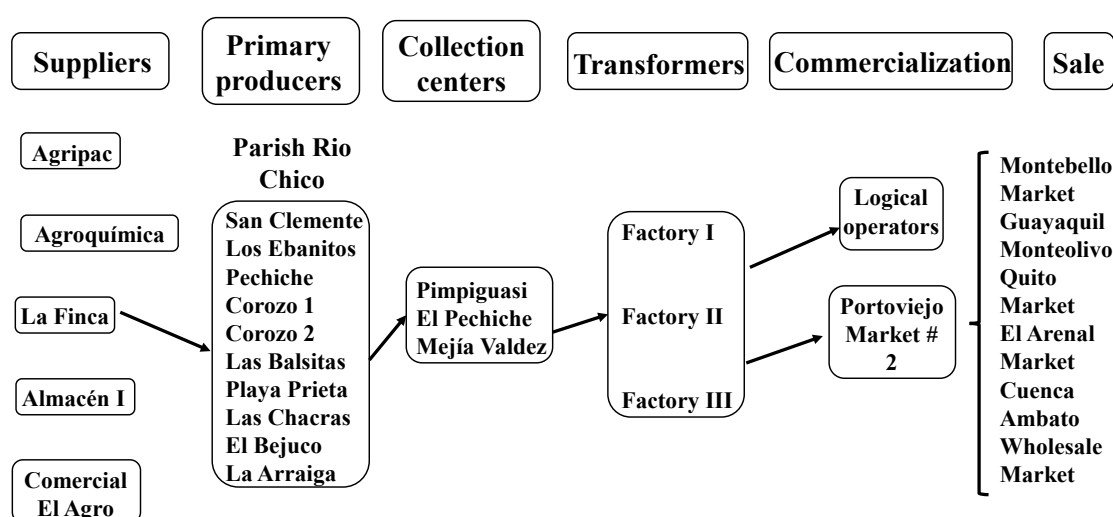
Figure 1. Lime agro-chain.

Primary producers. In Riochico there are 300 ha of cultivated lime with 500 producers. The areas with the most production are: Las Balsitas, El Corozo, Los Ebanitos, Santa Marta, San Francisco, Las Chacras, El Bejuco, Los Casinos, La Arriaga, La Encantada, Quebrada de Morales, El Pechiche y San Clemente.

The majority of producers do not have a university degree and their methods are empirical. They work based on the knowledge passed down from their ancestors, since there is little instruction and training from either state or private agricultural institutions.

The average producer is between 40 to 60 years old, because the younger population involved in the agricultural sector prefer to work in the collecion centers as sellers. Collection centers. These places serve to store lime and distribute them in great quantities on trucks to wholasale markets in the main cities of the country. The most important collection centers are located at Pimpiguasi.

Transformers. These are the businesses that provide added value to lime production, through processing

or transforming it into lime-based goods. Some of these businesses that is linked to lime production in the Riochico parish are: Factory I, at the Corozo sector, which exports frozen lime to Russia; Factory II produced pulp, juice and other products with lime as raw material. This factory is located at Rumiñahui, Pichincha province, but their lime plantations are in Riochico. Factory III processed pulp from citric fruits such as: orange, mandarin, lime and passion fruit. This factory was located at municipality of Chone.

Commercialization. Lime production is sold mainly through middlemen to wholesale markets in Guayaquil, Quito, Ambato and Cuenca. They are also sold in lower volume at Ibarra and Santa Elena. Likewise, lime was sold in lower proportion to the actors: factory I, II, and III for industrial purposes and export.

Sale. Lime from Riochico was sold at wholesale markes in the biggest cities of the country, such as: the Montebello Market of Guayaquil; the Monte Olivo in Quito; the Mercado Barral number 2 at Portoviejo; and the Mercado mayorista at Ambato.

Clients. The clients are the consumers that used lime for personal consumption, and the owners of businesses like restaurants, bars, cevicherias, among others.

The results from the integration check-list are shown in table 5. The highest values in the chain were: enterprise strategy, strategic objectives, forumulation of scenarios in the organization, demand forecast, purchases, stock management, providers, and goods distribution. The lowest values in the chain were: contracts, information, plans and performance indicators.

On the other hand, it was determined that 69% of chain actors showed a low NI level, while 21% showed a high NI level and 10% a very high NI level (figure 2).

Table 5. Selection of the types of strategies for the integration of the chain under study.

| Item of the supply chain model	Assessment of current status	Value
Business strategy	3.07	Average
Strategic objectives	3.06	Average
Formulation of scenarios in the organization	3.19	Average
Contracts	2.00	Low
Information	2.65	Low
Plans	2.86	Low
Demand forecast	2.93	Average
Purchases	3.00	Average
Stock management	3.01	Average
Providers	2.99	Average
Goods distribution	2.99	Average
Indicators for performance evaluation	2.25	Low
Clients	3.01	Average
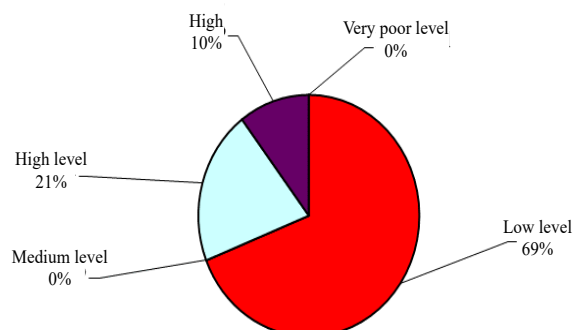
Figura 2. Evaluación del estado de desarrollo de la integración.

Based on these elements, the level of integration and strategies in the chain under study were identified. The chain under study was in the negotiation stage.

Therefore, in order to improve from the integration stage to the association stage, they should select the strategy of focusing on goods in critical processes for a single economic purpose or another interest. With the goal of reaching the partnership stage, the focus should have been on improving the contracts variable. This was defined in the diagnosis as the one with the greatest weakness.

The strategic objectives were:

To strengthen the use of contracts through the actors that contribute to the sustainability of other actors.

Stimulate the creation of logistical operators that can minimize the costs.

To develop products with added value that facilitate the maximization of durability, the rise of prices, and with that, the increase in profit for the producers.

Likewise, the check-list for evaluating integration was applied to other analyzed agro-chains in the province of Manabi, for example: raw cane sugar (Sablón- Cossío et al., 2016), milk (Sablón-Cossío et al., 2018), chocolate bars (Cañadas y Sablón, 2019), coconut (Romero et al., 2020) y organic arabica coffee (Negrín et al., 2020).

These six studies were carried out in Ecuador. The first three in the Amazon region, and the rest in the province of Manabi. The studies mentioned on this paper showed low and very low levels of integration, placing them at the negotiation and association stages. Therefore, the need to improve the agro-chains in the region became evident.

The most expansive study was donde on the coconut agro-chain. It encompassed 162 actors in the chain. The most affected variables in this case were information and performance indicators. At the same time, the circular economy and the level of development were also evaluated. This was the reason for the difference between the rest of the studies. With regards to the coffee arabica chain, the weakest variables were: goods distribution and information. The reach for this study was lower. The rest of the variables went between very low and average. There was a preliminary study for this case, due to the number of actors involved.

Conclusions

The analysis of the lime agro-chain in Manabí, and in particular in the Riochico parish, was the main result of this research. These results show that the agro-chain has a low level of integration. At the same time, the agro-chains must apply the strategies to reach the association stage between its actors. Because if this, the only strategy is focusing on a good in critical processes for a sole economic purpose or other interest. This research is useful for the agro-chain, and is the start of further research in logistics for the study case.

Conflict of interests

The authors declare that they have no conflicts of interest in this publication in any of its phases.

Bibliographic references

Abadia, M. B., Urcola, H. A., Ferrari, M. C. y Bartosik, R. E. (2020). Radiografía del sistema de acopio de granos en Argentina: ¿estamos preparados para acopiar más granos y preservar su calidad?. *INTA DIGITAL Repositorio Intitucional Biblioteca Digital*. https://inta.gob.ar/documentos/radiografia-del-sistema-de-acopio-de-granos-en-argentina-%C2%BFestamos-preparados-para-acopiar-mas-granos-y-preservar-su-calidad

Anaya Cruz, B. (2015). Las cadenas productivas con impacto económico y social: El caso de los cítricos en Cuba. *Economía y Desarrollo, 154*(1), 105-117.

Bazurto Párraga, L. C. (2022). *Modelo de gestión administrativa para centros de acopio de productos agrícolas en el cantón Bolívar*. Master's Thesis, ESPAM MFL. Calceta, Ecuador.

Cañadas Salazar, I. L. y Sablón-Cossío, N. (2019). Análisis de la cadena de suministro de cacao en el contexto de la Amazonia ecuatoriana. *ECA Sinergia*, *10*(2), 17-28.

Cocco, M. (2016). *Estudio del efecto de las distintas etapas del procesamiento mínimo de frutos cítricos sobre su calidad interna global*. Universitat Politécnica de Valéncia. España.

Daboin H., O., Martínez L., E. y Segovia L., E. (2005). Descripción del proceso de comercialización de la panela, estado Trujillo, Venezuela. *Rev. Fac. Agron. (LUZ) , 22*(1), 76-89.

Guanoluisa Rey, D. M. (2018). Caracterización de la comercialización de limón en la Asociación de Agricultores y Citricultores Primero de Mayo de la Comuna Barcelona, provincia de Santa Elena. Tesis de Pregrado. Facultad de Ciencias Agrarias, Universidad Estatal Península de Santa Elena. Ecuador. 58 p. https://repositorio.upse.edu.ec/handle/46000/4492

Instituto Nacional de Estadísticas y Censos (INEC). (2019). *Encuesta de superficie y producción agropecuaria continua* (ESPAC) 2019.

Negrín Sosa, E., Sablón-Cossío, N., Intriago Alonzo, F. A., Zambrano Basurto, Á. M. y Acevedo Urquiaga, A. J. (2020). Aplicación del CPFR en una cadena agroalimentaria de café arábico en Manabí (Ecuador). Caso de estudio Calceta. *Espacios*, *41*(3), 23-35.

Nicolás N., O. y Favila T., A. (2019). Competitividad de México en la exportación de limón a países bajos. *Actualidad Contable Faces, 22*(39), 93-111.

Organización de las Naciones Unidas para la Alimentación y la Agricultura (FAO). (2020). Las principales frutas tropicales: análisis del mercado 2018.

Orús, A. (2022). *Ranking de los mayores países productores de limones y limas a nivel mundial en 2020, según la cantidad de producción.* https://es.statista.com/estadisticas/613493/principales-paises-productores-de-limon-en-el-mundo/

Rizo Mustelier, M., Villa Tabares, B., Vuelta Lorenzo, D. R. y Vargas Batis, B. (2017). Estrategias de comercialización para la gestión de ventas en el Mercado Agropecuario Estatal Ferreiro de Santiago de Cuba. *Ciencia en su PC, 4*, 91-102.

Romero Delgado, V. M., Rosado Zambrano, G. V., Sablón-Cossío, N. y Burbano Mera, L. (2020). Análisis de la cadena agroalimentaria del coco (*Cocos nucifera*) en la provincia de Manabí, Ecuador. *La Técnica*, *24*(2), 43-72.

Santistevan Méndez, M., Helfgott Lerner, S., Loli Figueroa, O. y Julca Otiniano, A. (2017). Comportamiento del cultivo del limón (*Citrus aurantifolia* Swingle) en "fincas tipo" en Santa Elena, Ecuador. *Revista Científica y Tecnológica UPSE, 35*(1), 45-49.

Sablón-Cossío, N., Pérez Quintana, M. L., Acevedo Suárez, J. A., Chacón Guerra, E. y Villalba Pozo, V. (2016). La integración en la cadena agroalimentaria de panela en el Puyo-Ecuador. *Cultivos Tropicales*, *37*(4), 128-135.

Sablón-Cossío, N., Hernández Nariño, A., Urquiaga Rodríguez, A. J., Acevedo Suárez, J. A., Bautista Santos, H. y Acevedo Urquiaga, A. J. (2017). Matriz de selección de estrategias de integración en las cadenas de suministro. *Revista de Ingeniería Industrial*, *XXXVIII*(3), 333-344.

Sablón-Cossio, N., Orozco Crespo, E., Ruajo, A., Acevedo Suárez, J. y Ruiz Cedeño, M. (2021). Análisis de integración de la cadena de suministros en la industria textil en Ecuador. Un Caso de Estudio. *Revista Ingeniar2*, *29*(1), 94-108.

Valarezo Beltrón, C. O. (2021). Sustentabilidad de fincas productoras de Limón (*Citrus aurantifolia* (Christm) S.) en el cantón Portoviejo, Ecuador. Tesis Doctoral. Doctorado en Agricultura Sustentable, Escuela de Posgrado, Universidad Nacional Agraria La Molina. Perú.

Valencia Sandoval, K. y Duana Avila, D. (2020). Los cítricos en México: análisis de eficiencia técnica. *Análisis Económico, 34*(87), 269-283.

Authors contribution

Author	Contribution
Javier Gregorio García Arteaga	Appplying the integration check-list, literature review, analysis and interpretation of data, writing and reviewing the manuscript
Neyfe Sablón Cossío	Reasearch design, data interpration and review,writing the manuscript, style correction
Sebastiana del Monserrate Ruiz Cedeño	Reviewing the content related to the agro-chain, and correcting it. style correction.