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DESCRIPTION OF THE PRODUCTIVE, POST-HARVEST AND COMMERCIAL PROCESS IN THE BANANA VALUE CHAIN OF CERRO DE ORTEGA

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ABSTRACT

The agro-food chain of the Dwarf Giant banana variety (Musa AAA subgroup Cavendish), is considered one of the most important among the agricultural chains in the State of Colima; however, it faces problems such as the high cost of production inputs, disorganized producers, elevated number of intermediaries, price speculation, and loss and waste of fruit by work teams during the harvest and packing of bananas, because of failure to reach the quality demanded by the client. This research aims to analyze the production, post-harvest and marketing procedures of the Dwarf Giant banana value chain, in Cerro de Ortega, Tecomán, Colima, by describing the participating agents and calculating the average cost of production. To do this, semi-structured surveys were applied using non-probabilistic convenience sampling, taking into account the possibility of accessing the population in the study area. As a result, we managed to charactize production, commercial and post-harvest processes, while also calculating production cost per kilogram. This was $3.19 pesos per kilo, exceeding the average minimum sale price achieved by producers in the area, during the last year.

Keywords: marketing, production cost, waste

INTRODUCTION

In 2022, Mexico produced 2,593,025 tons of bananas, which led to it taking 19th place worldwide as a producer of this fruit, generating exports of 295 million dollars, during this particular year. In Mexico, the per capita consumption of bananas is 14.5kg. The states with the highest production indicators of this fruit are Chiapas (654,156 t), Tabasco (622,175 t), Veracruz (335,238 t) (South-Southeast region), Colima (324,132 t), Jalisco (202,742 t) and Michoacán (179,220 t) (Central-West region); The South-Southeast region produces 63% of the total national production and the Central-West region produces 27% of production (SADER-SIAP, 2022).

The State of Colima contributes 12.5% of national production; the area harvested for bananas in the state went from 6,099.5 hectares in 2021 to 9,555.5 hectares in 2022, representing an increase of 38% of state production,

during these years. The main producing municipalities are Tecomán (66%), Manzanillo (29%) and Armería (4%) (SADER-SIACON, 2022). SADER (2019) indicates that 40% of production was exported by 15 companies, of which 7 have organic production certification.

In 2016, the State Council of Plantain Producers of Colima recognized 568 producers in its state register (a register that has not been updated since). Throughout the state, this generated more than 9,000 direct jobs for rural workers dedicated to processes involving production, cutting and packaging of fruit. At the national level, this activity generated around 100,000 direct jobs and 150,000 indirect jobs (García *et al*, 2013). This agri-food chain is notable for its position as the third most important among priority agricultural chains in the state (SADER, 2019).

Some of the problems faced by producers in the banana value chain in the State of Colima include the high cost of inputs needed to carry out the production process (resulting in poor fruit quality), bananas wasted during packaging, disorganization of producers, middlemen and speculation concerning prices paid to the producer.

These problems have caused concern, instigating an investigation that aims to analyze the production, post-harvest and marketing processes of the banana value chain (Musa AAA subgroup Cavendish) in Cerro de Ortega, Tecomán, Colima, in order to characterize participating agents and calculate average production cost.

The research hypothesis establishes that producers face high production costs, as they carry out more activities in their process than other agents in the chain; at least 500 kg of banana cut by each producer are wasted during the post-harvest process, which results in excessive fruit waste and at certain times of the year, prices paid to the producer fall below the cost of production.

THEORETICAL FRAMEWORK

Various approaches and meanings have been applied to the term value chain, making it difficult to arrive at a definition. In order to understand this, one must first identify the context in which the chain is being discussed, in terms of the socioeconomic reality. The value chain is a system that groups together interrelated actors, who participate in activities that add value to a good or service, from the time of production until it reaches consumers, including suppliers of inputs, transformation, industrialization, transportation and services (consulting, logistics, financing, among others). The relationship is not exactly linear; it more resembles a network of interactions between the actors involved, which may not be divided equitably. In short, from the socioeconomic point of view, the agri-food chain represents a reality that is

not necessarily fair; the value of a product, good or service is often distorted (Figueroa-Rodríguez *et al*., 2012).

A value chain comprises a series of activities, necessary to take a product or service from its production, through the different stages, until it reaches the hands of the final consumer. This includes those who participate in production, agroindustry, distribution, marketing and also consumers (Abundiz-López, 2017). Brambila-Paz (2011) pp 199-200, defines the value chain as a "sequence of activities in the food production chain that generate value for the consumer and for the participating companies, by achieving greater efficiency and optimization"; in this way, a value chain aims to offer a product that the consumer considers to be of greater value (the consumer is placed as the central axis of the value chain).

In this sense, the concept of value chain can be defined as the contribution of all the actors and processes involved in the transformation of a product of agricultural origin, from its production on the farm by a farmer, until it is purchased or acquired in the form of a product by the final consumer (SAGARPA, 2015).

The value chain, as a unit of analysis and formulation in the design of policies, is an important factor for two fundamental reasons: firstly, because it allows us to understand and value the contribution of agriculture to the country's economy, and secondly because the proper functioning and adequate articulation between its different agents are fundamental components for increasing the competitiveness of the agricultural sector and the economy of countries. Competitiveness is a comparative concept based on the dynamic capacity of a spatially located value chain to maintain, expand and improve its participation in the market, both domestic and foreign, in a continuous and sustained manner. This occurs by means of the production, distribution and sale of goods and services in the time, place and manner requested, seeking as the ultimate goal; society's benefit (Sepúlveda, 2002).

One of the fundamental axes that determine the functioning of a chain lies in its actors, who can have functions ranging from production, supply and marketing, and even consumption. Their relevance lies in constituting those who really move the flows in the chains by their decisions and actions. In this sense, it is important to understand the relationships between the actors and how these are articulated, to determine the degree of influence they have on the chain and in the area (Figueroa *et al*., 2012).

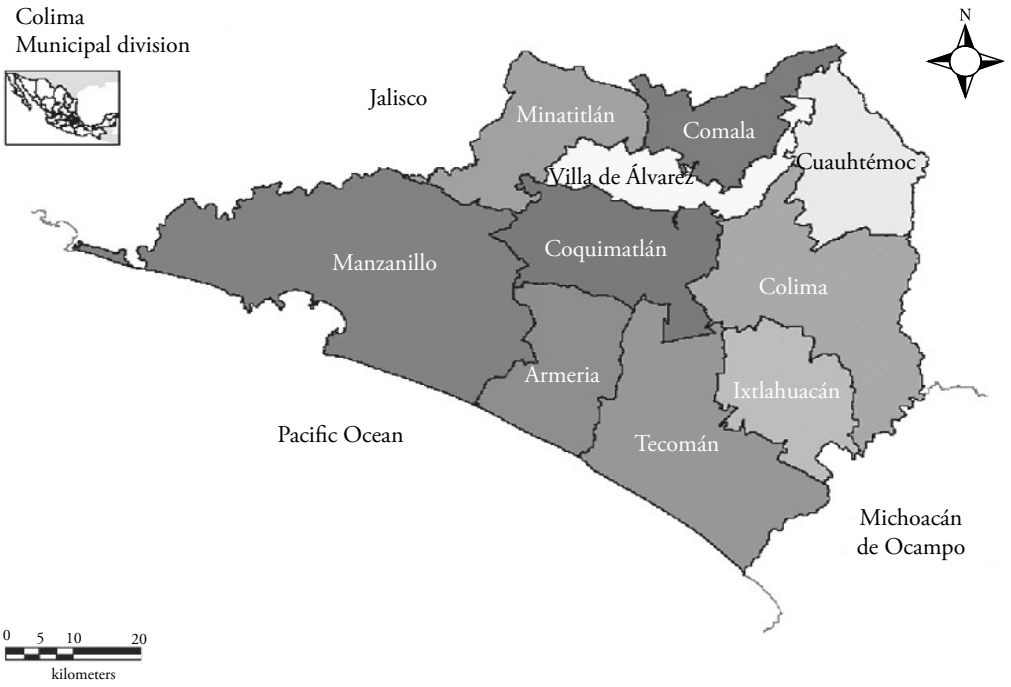
According to Rojas-Rojas *et al*., (2023) there are various methodologies and tools to address the analysis of the value chain. These methodologies include:

- Porter (2003): This is based on the disassociation of the main primary and support activities of a company, which generate value for the product or service that exceeds the cost of creating the product while generating competitive strategies, which then become a strategic procedural mode for the company. This situation is analyzed in terms of cost; the differentiation and contribution derived from the ability to diagnose, achieve and maintain competitive advantage. The competitive advantage that he refers to is based on the creation of value that a company generates for its clients or consumers. This created value represents the extra that the consumer is willing to pay, either because it reduces their transaction costs or generates a plus in terms of the use of that product or service.
- Economic Commission for Latin America and the Caribbean (ECLAC, 2017): This tool is based on an in-depth diagnosis that identifies systemic restrictions in relation to stage, to subsequently link the actors to the stages involved, identifying bottlenecks that prejudice the creation of value in the chain, placing greater emphasis on innovation systems and product development, so that finally, strategies are defined to promote the linkage between stages, as well as the integration of new actors and economic and social escalation, with the help of institutional support.
- Link: This methodology makes it possible to visualize the business models of the actors involved, in order to understand how the value chain works. It proposes drawing a map to help identify and comprehend how the chain works as an overall system. It enables identifying the role played by each participant, the flow of information, products and payments, while improving communication between actors and identifying bottlenecks to improve procedures, so that an innovation prototype for the business model can be designed and implemented. This methodology points out three components in the chain: 1) direct actors, 2) indirect actors and 3) contextual influences, Lundy (2014).
- The FAO (Food and Agriculture Organization of the United Nations) methodology, described by Da Silva and de Souza (2007), characterizes the value chain activities that create value, while evaluating the chain's performance in terms of identifying weaknesses and strengths for its development. These activities allow participating agents and public policy makers to implement corrective measures for territorial development with growth potential. It allows for the creation of a shared vision among the chain's actors to facilitate the development of collaborative relationships. This tool promotes business development, improves food quality and safety, measures added value, while promoting links between chain actors: producers, processors, marketers. It also reviews the competitive position of an individual company in the market, among other activities.

Each methodology manifests a particular characteristic, depending on the approach or objective that frames the analysis. The most widely used tool for analyzing the value chain is mapping, which plots graphs and presents the value chain in a simplified manner. It also identifies the current state of the flow of the product or service until it reaches the hands of the final consumer; likewise it indicates the flow of information between participating agents (Nutz-Sievers, 2016).

Defining the study area

This research was carried out in the municipality of Tecomán Colima (Figure 1), located in the southeast of the state, between the parallels 18°40′ and 19°08′ north latitude and the meridians 103°37′ and 103°59′ west longitude, with an altitude ranging between 0 and 1,200 meters above sea level. To the north it borders with the municipalities of Coquimatlán and Colima, to the east with Ixtlahuacán, to the south with the Pacific Ocean, to the west with Armería and to the southeast with the State of Michoacán. (INEGI, 2010) The territorial area of Tecomán measures 788 km2; it has a population of 116,305 inhabitants, of whom 57,829 are men and 58,476 are women (INEGI, 2020).



Source: INEGI, 2005, Municipal Geostatistical Framework 2005
Figure 1.- Map of study area location.

The second most populated locality in the municipality is the town of Cerro de Ortega, with a population of 9,309 inhabitants, located 26 km away from the municipal capital; the area is predominantly agricultural and constitutes the strongest banana producing area in the municipality of Tecomán (INEGI, 2020).

METHODOLOGY

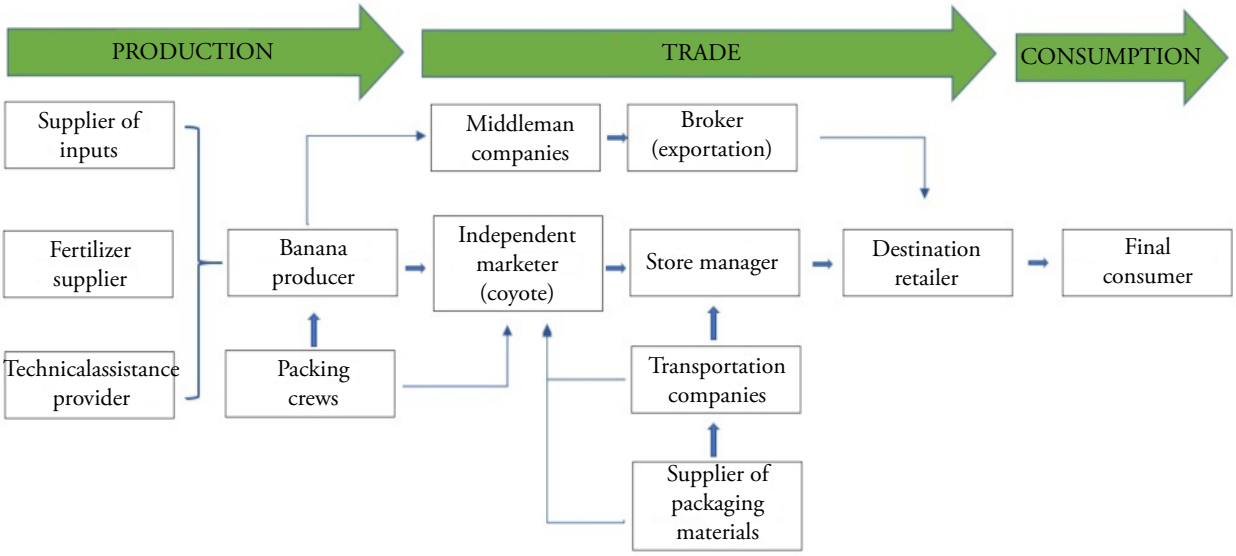
Research design

The study was designed as exploratory, descriptive research, involving a process of collecting and analyzing quantitative and qualitative data, divided into three stages: the first consisted of a literature review and the design of semi-structured surveys to collect information related to the processes of 1) production; 2) harvest and; 3) marketing. The second was the fieldwork phase, when information was collected in the town of Cerro de Ortega, where 80 producers are registered in the records for the local Association of Plantain Producers in Cerro de Ortega, Tecomán, Colima. To collect information, we used non-probabilistic convenience sampling, described by Otzen and Manterola (2017), as a type of sampling that permits the selection of accessible cases, who agree to be included in the study, based on convenient accessibility and proximity of subjects for the researcher. This methodology helped in the collection of information in the field, due to the difficult access conditions and availability of producers to be interviewed, given that in the study area, there are problems of insecurity and organized crime. 20% of all producers in the locality were interviewed, during the month of October 2022. The third phase involved the processing and analysis of field information, which was systematized in a database that was processed on a spreadsheet of the Microsoft Office 2019 Excel program, in order to calculate and analyze response variables. The quantitative variables (number of hectares per producer, number of plants per hectare, tons of fruit harvested, input costs, sales prices, among others) were analyzed using descriptive statistics. Additionally, information was obtained by bibliographic review and analysis of official databases, such as those provided by the Agri-Food and Fisheries Information Service (SIAP) and the Agri-Food Information System for Consultation (SIACON).

RESULTS

Identification of actors in the banana value chain

Information collected in the field, was used to identify the agents involved in the production, post-harvest, and marketing processes of the banana value chain in the town of Cerro de Ortega, Tecomán, Colima (Figure 2). Rojas-Rojas *et al*., (2023) indicated that there are direct and indirect actors in the value chains. In the field, primary producers, independent marketers (coyotes), packing crews



Source: self-elaborated based on fieldwork information, 2022.
Figure 2. Diagram of the banana value chain in Cerro de Ortega, Tecomán Colima.

(post-harvest process workers), warehouse workers, destination retailers, and finally consumers were identified as direct actors, whereas indirect actors included technical assistance providers, input suppliers, fertilizer suppliers, transportation companies, and packaging material suppliers.

Production Stage

The first stage in the banana agri-food chain in Cerro de Ortega, Tecomán, Colima, is production, and the participating agent is the producer. 92% of producers interviewed define agriculture as their main activity and source of economic income, with an average of 23 ± 12 years of experience in banana production. 100% of producers are men. Regarding land ownership, 66% stated that their plantation lies on communal land, while 34% own a small property. On average, the producers have access to 13 ± 11 hectares of land surface for cultivation, and 67% of farmers have a water concession for irrigation that they pay to the local water committee. The average price for this service is $1,650.00 per hectare, per year, while the remaining 33% of irrigation is supplied by river water.

For banana production, producers require suppliers of inputs and technical assistance for plantation maintenance. Apparently, 66% of producers acquire these supplies from marketing companies located in the municipal center of Tecomán, which is 26 km away from the town. 17% of them acquire inputs in

the municipal capital of Coahuayana, Michoacán, which is 12 km away. The remaining 17% get their supplies in their local town, Cerro de Ortega.

The supply of inputs is directly related to the technical advice received by producers, 59% of whom receive this from input marketing companies, provided by agricultural engineers who distribute their products among the plots. 25% of producers interviewed, stated that they do not receive or have access to technical assistance; 8% have received technical advice from other institutions such as the National Institute of Forestry, Agricultural and Livestock Research (INIFAP) and the remaining 8% receive technical advice from their own children, as they are agricultural engineers.

Production process

In the study area for banana production, the average planting density in the plots is 2,100 ± 156 plants per hectare.

Banana cultivation depends on numerous cultural tasks to ensure optimum development of the plant and these are carried out at the different physiological stages of the crop. According to SAGARPA (2013), these activities include:

- Weed control: This is undertaken in three ways: manually (using a machete), by applying herbicides and by growing ground cover crops.
- Thinning of seedlings: This consists of selecting and controlling the number of seedlings per plant, eliminating undesirable shoots. Seedlings selected must consist of the most vigorous examples, located in spaces between mother plants.
- Leaf removal (cleaning): This consists of removing dead leaves that hang from the plant due to the effect of wind or any damaged by Sigatoka disease.
- Flower removal: This task involves removing floral residues from fruit in formation, reducing damage caused by rubbing, while decreasing the incidence of thrips.
- Removal of excess: This consists of removing false shoots and the next one or two considered not to have the potential to reach the minimum size required, favoring the development of those remaining. This activity is carried out from the bottom to top of the banana bunch stalk.
- Removal of tassels: The tassel or acorn, representing the set of unproductive male flowers, is removed following the formation of all the hands on the banana bunch stalks.
- Bagging: This is undertaken to avoid damage caused by low temperatures. A perforated nylon bag treated with agrochemicals is placed over the banana bunch stalk, to completely cover it. Likewise, the microclimate that forms inside the bag shortens the period between flowering and cutting.

- Tape: This aims to homogenize the fruit harvest, based on age. The bag is tied to the rachis on the banana bunch stalk with colored plastic tape. The same color is used for all bunches bagged during that week and 10 to 12 colors are used per year.
- Tying or shoring: To stop grown plants from falling over, they must be propped up using supports consisting either of forked wooden props or rope (string, nylon straps).

In the field, it was found that 100% of the producers carry out weed control, in 59% of the cases, this is undertaken in a semi-mechanized way, with the use of brush cutters; 33% do this by applying agrochemicals and 8%, manually, using a machete. 100% of producers tidy up the plants, by weeding, flower removal, removal of excess, removal of tassels, tying, taping and bagging. Two additional cultural tasks are also carried out in the region, consisting of arranging and thinning out the leaves, both undertaken by 75% of the interviewees.

These activities are carried out constantly throughout the week and are performed by two different types of agricultural workers. The first type of worker, known as an "Ariero", is responsible for flower removal, removal of excess shoots, bagging, taping and tying, each one of them covering an area of 10 hectares per day and earning an average income of $350 per day. The second type of worker, known as a "Pordiero", is responsible for weed control, weeding, thinning, bed clearing, and applying fertilizers and agrochemicals, depending on what the producer deems necessary in the plantation. They earn an average salary of $250 per day. Both types of workers are part of the permanent labor force employed in the plantation by the producer and work an average of 6 days a week. Fieldwork revealed that 67% of farmers have this type of hired labor with an average of 7 workers, depending on the size of the plantation. It is estimated that the producer spends on average $66,588.03 per hectare per year on these procedures (Table 1).

In addition to cultural tasks, producers must carry out other activities as part of the production process, necessary for the optimal development of

Table 1. Average cost of cultural management of banana crops.

Concept	Average Cost /ha
Irrigation permit	$ 1,650.00
Bags	$ 9,398.69
String	$ 11,782.91
Labor	$ 43,756.43
Subtotal	$ 66,588.03

Source: self-elaborated based on data obtained during fieldwork, 2022.

the crop, such as fertilization and also pest and disease management. 100% of producers fertilize their plantations, 75% of them declared to have their own fertilizer formula (formulas composed of commercial fertilizers in varying concentrations; either liquid or granulated). The remaining 25% use conventional granulated fertilizers; out of the total number of producers, 16.6% use DAP phosphonitrate and 8.4% use ammonium sulfate, potassium chloride and triple 17. It is estimated that the producer spends on average $34,412.61 per hectare, per year on these procedures (Table 2).

Regarding management of pests and diseases among banana crops, a very strict schedule is required in order to apply specific agrochemicals to combat black Sigatoka (*Mycosphaerella fijiensis Morelet*). This is the disease with most impact affecting the commercial production of bananas and plantains; in most production regions throughout the world. This has caused serious losses in the commercial production of bananas and necessitated modification to plantation management, mainly, in the form of chemical control programs. This causes an increase in the production costs of the crop. Currently, the fight against black Sigatoka in bananas mainly relies on continuous application of fungicides (Orozco *et al*., 2008).

100% of producers apply treatments to combat black Sigatoka on average every fortnight in the dry season and every 10 days in the rainy season. To carry out this activity, producers use light aircraft (67%), sprayers (17%), drones and tractors (16%). Complementary treatments are also applied to the plant to improve its functions, including resins (50%), amino acids (34%), hormones (59%), penetrants (50%), pH improvers (67%), adhesives (50%), soil improvers (50%) and root enhancers (67%). It is estimated that the producer spends an average of $27,471.08 per ha per year on these items (Table 3).

Harvest

According to the information collected during fieldwork, apparently it takes an average of 10 weeks, from the time the perilla or acorn sprouts on the plant, for the banana bunch to mature and be ready for harvest. 100% of banana

Table 2. Average cost of nutrients for banana cultivation.

Concept	Average Cost/ha
Fertilization	$ 30,992.50
Chemical complement	$ 3,420.11
Subtotal	$ 34,412.61

Source: Self-elaborated based on data obtained during fieldwork 2022.

Table 3. Average cost of pest and disease management for banana crops.

Concept	Average Cost/ha
Mechanized pest management	$ 7,200.00
Chemical pest management	$ 2,550.00
Aerial Fumigation (flights)	$ 17,721.08
Subtotal	$ 27,471.08

Source: self-elaborated based on data obtained during fieldwork 2022.

growers stated that they carry out an activity called "encinte" to identify the age of the plants. This consists of placing a different colored ribbon on the rachis of the bagged bunches, every week. In this way, the age of the plants in the plantation is monitored. This provides a fundamental guide for the harvest of the banana bunch stalks; so that each week, the color of the ribbon that corresponds to the required maturity of the fruit ready for harvest throughout the plantation, enabling the producer to keep a schedule of the number of banana bunch stalks that can be cut. Fieldwork revealed that this activity is carried out by 100% of producers.

Regarding the quantity of fruit harvested in the region, the farmers interviewed stated that they obtain an average of 23 ±11 t/ha per year. All producers are familiar with their conversion rate from bunches to boxes, which allows them to evaluate their technological efficiency. In general terms, the average conversion rate is around 1.5 boxes per banana bunch stalk, with a margin of error of ±0.18 boxes.

Post-harvest process

Bananas require a particular post-harvest process. Producers hire specialized workers to cut and pack the fruit. This group of workers is known as a "crew" and is responsible for cutting, transporting (by cable car or on their shoulders), unpacking, dismantling, selecting, washing, labeling, sealing, packing and storing the fruit. These activities vary according to the client's specifications, the market destination, the quality of the fruit in the plantation, the packaging required by the product and the type of transportation by which it will travel. 100% of producers interviewed stated that plastic waste is generated during banana production, consisting of plastic bags, cord and agrochemical containers. Used and discarded bags and cord are piled up in an area within the plantation, with the intention of being donated for subsequent recycling; the producer does not obtain economic benefits from this material. Plastic recyclers are responsible for collecting, storing, transporting and selling this waste to recycling companies.

100% of the producers stated that they face a serious problem related to the considerable amount of fruit that is discarded during the banana cutting and packing process, undertaken by the crews. This is because not all the fruit cut meets the commercial specifications required by the clients, either in terms of length or thickness. Physical discrepancies in the fruit suffice for it to be discarded. During the post-harvest stage, the waste generated consists of the stems of the banana bunches and all the bananas rejected by the workers. On average, each producer generates 1,250 kg of banana waste in each harvest. These discarded bananas are offered as gifts to people who raise cattle in the region. The only condition for receiving this waste is that these people are responsible for collecting it from the farm, as from the perspective of the producers, assigning an employee to clean the packing yards implies an additional expense.

Commerce

The concept of a marketing or distribution network was first used to describe the existence of a trade route that bridges the gap between producers and consumers. Early researchers compared distribution networks to routes by which goods or materials could pass from producers to users. The function of a distribution network is to connect products to markets and establish a route by which sellers and buyers can negotiate. However, the most technologically advanced, best designed and most innovative distribution network will be of no use, if they do not receive adequate products to sell in the appropriate markets (Vásquez, 2009).

Fieldwork showed that producers can have two commercial distribution routes, the first of which is the most common; for this, the producer, the independent marketer (coyote) and the storekeeper (customer) are related. The marketer (coyote) goes to the producer's farm to negotiate the harvest and set a purchase price, later he speaks with the storekeeper to set a sale price and to request the truck or King thermos, which will transport the fruit; the type of transport will depend on the distance from the final destination, the type of packaging to be used and the quality of the fruit to be sent; under this commercial scheme and from the producer's perception, the costs generated during cutting and packaging are being saved, whether in mobile packaging or in fixed packaging, as they are covered by the marketer (coyote). The average cost per harvest of the labor for packaging; in the case of a Torton type truck, packed in a wooden box, amounts to $14,000.00, whereas in the case of a Termo King type truck, with a refrigerated box and packed in a cardboard box, the average cost per harvest is $22,000.00. These costs depend on the number of people that make up the crew and the specific activities that need to be carried

out; therefore, on average, the payment for crews is $39,526.46; this type of sale occurs in 67% of cases.

In the case of the second marketing route, the collecting companies send their commercial agents to negotiate with producers, who provide the quality of fruit required by the company. In this agreement, the company establishes the commitment to buy from the producer and for a fixed purchase price to be respected throughout the year and the farmer will assume the commitment to supply fruit exclusively to the company and to respect the price that was established for the period of the agreement. Later, the company sends the fruit to a broker for export. Generally, this scheme is managed by producers who have fixed packing facilities on their ranches, so that at the time of harvesting the banana, the company sends its crew to carry out the activities of cutting and packing, ensuring that the fruit meets the specifications that the client demands. Likewise, from the producer's perception, he saves on post-harvest costs; it was found that this sales dynamic is carried out in 33% of cases.

In both cases, the producer thinks that he does not pay the cost of the crew, but when it comes time to do the math, the marketer assigns that concept to the producer, however, the marketer (coyote) receives a deposit from the client or grocer for the payment of the crew, so the marketer has a profit both in terms of the margin between the purchase and sale of the fruit and then because of the lesser amount that he pays to the producer to include the concept of labor payment.

Regarding the allocation of price of fruit at time of sale, 67% of the producers stated that marketers set the prices at which the bananas are to be purchased; 25% of producers stated that they have a verbal agreement with the collecting company and the remaining 8% stated that the purchase price is set by the local association of banana producers in Cerro de Ortega.

Regarding the form of payment that marketers use to purchase fruit locally, evidently 25% of producers are paid in cash on the same day the fruit is packed, while 75% of them must agree to give independent marketers an 8-day credit, or 30 days, in the case of producers who work with collecting companies; the average minimum price at which producers have sold in the last year is $2.3 per kg, whereas the average maximum price at which they have sold is $6.0 per kg, arriving at an average annual price of $4.15 per kg. 100% of producers have declared that, during the year 2022, historical maximum sales prices were recorded, coinciding with the average rural price of the year for the years 2021-2022, which was $4.06 per kg, SADER-SIAP (2023).

Target Markets

The banana market depends on the quality and quantity of the fruit harvested. The quality of the fruit defines the market that producers can access. Although

in the study area, there were producers and companies with sufficient quality to export all their fruit production, these depend largely on the quantity they can obtain per harvest and the cultivated surface they have to harvest, which, in many cases, is not sufficient to send complete shipments. For this reason, buyers are forced to look for another producer who can complete the shipment, under the premise of having the same quality of fruit as the first, which implies one more maneuver on the part of the buyer, thus causing extra costs. This causes buyers to develop a preference for larger producers, meaning that small and medium producers are left behind.

The rest of the producers who do not have fruit that meets export quality, also known as premium quality, are destined to sell their production in the national market (these represent the majority); these producers have fruit with first and second national quality.

Fieldwork indicated that 75% of producers know the destination of their production; the most mentioned national destinations are the supply centers of Mexicali, Tijuana and San Luis Potosí. In the warehouses of the supply centers, the product is received and stored in ripening chambers, where it is gassed with ethylene in order to reach uniform ripening, suitable for human consumption; subsequently, it is sold to retailers who distribute it and make it reach the final consumer, through public markets, street markets (tianguis), grocery stores, fruit stores and supermarkets; this coincides with the main routes to market destinations, defined by Schwentesius and Gómez (2005) in Mexico, by which food products reach consumers.

Principal routes

I. Public Markets
- Location: In the city center.
- Managed by municipal governments.

II. Street markets (Tianguis)
- These change location daily and are set up in communities and neighborhoods.
- Market day: These offer a variety of products similar to supermarkets, but of lower quality.
- They provide proximity to the consumer.

III. Conventional Grocery Stores
- These offer a reduced number of basic necessities.

IV. Fruit stores
- These offer fruit and vegetables, with fruit conveniently on view.

V. Self-service stores (supermarkets and convenience stores)

- These offer a wide variety of food and non-food products.
- These focus on convenience and self-service for customers.

As for international destination markets, there include: Japan, Singapore and South Korea.

Production Cost

To calculate the average cost of production per kg of plantain in Cerro de Ortega, Tecomán, Colima (Table 4), production costs were analyzed, expenses incurred throughout the production and post-harvest process were accounted for, and the following costs were taken into account: labor, pest and disease control, fertilization, management of Black Sigataka, costs of inputs such as bags, string, tape, agrochemicals, cutting and packaging, as well as the yields obtained during the harvest; the average production cost calculation in the study area is $3.19 per kg produced.

Seasonality of sales and price behavior

Agricultural production, unlike what happens with other sectors of economic activity, has a marked seasonality (seasonality is when a product is produced or sold to a greater or lesser extent, at different times of the year). This is linked to the evolution of the biological cycle of each crop, which, in turn, is related to the characteristics of the climate of each region. Thus, the seasonality of most agricultural crops develops throughout the year. The same situation does not occur with prices, as these depend, in addition to production, on factors such as: transportation costs, product cleaning, packaging, labor costs, as well as imports or exports of the product. However, the months in which crop prices tend to increase to a greater or lesser degree were identified SAGARPA (2003). It has been pointed out that consideration of the seasonality of supply is of great importance in agricultural product markets, caused mainly by the particular characteristics that condition the agricultural production process. By seasonality in supply, we understand the variation in the supply function

Table 4. Average production cost per kg of banana.

Concept	Quantity
Total cost ($/ha)	$ 167,998.18
Average production (kg/ha/año)	52,645.17
Average cost of production ($/ kg)	$ 3.19
Benefit cost relation	1.30

Source: self-elaborated with data obtained from fieldwork 2022.

(supply-price) experiences, that occur throughout the different periods of the year; seasonality refers fundamentally to the offers that have been defined as "short-period offers", that is, a large number of agricultural products are collected during a short period of the year. If the product is not perishable, as occurs for example in the case of cereals, legumes, cotton, etc., storage allows the product to be offered throughout the year; but when the product is perishable, the seasonality of supply can be very pronounced, as it largely coincides with the seasonality of production; this is the case of many fruits and vegetables, due to the impact of the environment or the use of natural resources (Bejarano, 1998). In the field, producers indicated that the production volume depends largely on the climate in the region and the increase in temperature during the different times of the year; in this sense, the production volume increases during the period from May to November; banana production is sensitive to the increase in temperature, which encourages the plant to develop faster in these months, meaning fruit sales increase during this period, whereas from December to April, banana production decreases, as the cold causes the plant to have slower development, causing production to be lower and therefore, sales to decrease.

This is why bananas are produced in the region all year round; however the supply and demand of the fruit in the locality and the state are very marked. As for price behavior, banana growers stated that during the months of July until mid-December, the price of the fruit decreases, while from mid-December until April, prices increase.

DISCUSSION

Productive process

The flow of the banana agri-food chain outlined in this research, based on information obtained from fieldwork, largely concurs with that described by SAGARPA (2015), in the study "Identification of factors for the optimization of the banana-plantain agri-food chain in the state of Tabasco". Likewise, regarding the production process, the field data for different variables, such as cultivated area and type of plantation, coincide with that described by Vázquez-Castrejón *et al.* (2005). For cultivation, planting in double furrows is recommended at 1 m between rows, with a separation of 2.5 m between each plant and, forming an equilateral triangle. This results in a distance of 3 m between each set of double rows. With this distribution, population density reaches 2,000 plants per ha, and during the first year of cultivation, it is estimated that 2,000 bunches per ha will be obtained.

This also coincides with INIFAP (2017), which establishes that, in the case of banana cultivation in the state of Veracruz, a planting system with 1.0 m of

separation between furrows, 2 m between plants and 4 m between rows is recommended, also arriving at a planting density of 2,000 plants per ha.

During the production process, one of the most important tasks, in addition to the cultural tasks that must be carried out, is the control of black Sigatoka. Chemical control programs were modified to combat this disease, making it necessary to use more powerful fungicides with shorter application intervals. It is estimated that combating black Sigatoka accounts for between 35 and 48% of the total production costs for the crop. Likewise, there were changes in the management of the plantations, with a tendency to implement greater technology in crop management (nutrients, population density, weeding, leaf removal, pest, disease and weed control), resulting in increased production costs. However, this also resulted in greater yield and quality of fruit per unit of surface, due to better agronomic plot management (Orozco *et al*., 2013).

In the producing regions of Tabasco, climatic conditions (2,500 to 3,000 mm of annual precipitation) promote disease development, so that 40 to 50 fungicide sprayings are required annually, mainly of the type offering protection and in lesser proportion, systemic. Contrastingly, in the Central Pacific region (Colima, Michoacán and Jalisco), 25 to 38 applications are necessary, whereas in the South Pacific, 35 to 45 cycles are required in terms of spraying programs for protectant fungicides, as well as systemic fungicides to a much lesser extent (idem).

Another key task at the beginning of the production process which serves as a basis for the marketing of the fruit is the taping of the banana bunch stalks; Rosales *et al*. (2010) point out that taping is essential for controlling the ripening of fruit and for properly planning the harvest. Taping is undertaken at the time the acorn appears, using colored tapes. It is also a way to quantify or account for possible profits or guarantee sales contracts. The amount of fruit harvested by producers in the field coincided with the data reported by SIACON (2022), which was 34 tons per ha per year in the State of Colima.

Post harvest

The banana is a climacteric fruit that reaches physiological maturity on the plant, but is not suitable for consumption at the moment of harvest. Over time, its physical and chemical properties change and it reaches organoleptic characteristics that are ideal for sale and subsequent consumption (León *et al*., 2002).

The post-harvest process is of great importance, as if these activities are carried out adequately, diseases in the fruit, such as crown rot, inadequate ripeness or lack of homogeneity in the ripening of the entire shipment, are prevented. This procedure is essential to guarantee the quality of the product and ensure that it reaches the final consumer in optimal condition (Riofrio, 2003).

Fieldwork revealed that during this activity and specifically during the fruit selection phase, when banana bunch stalks are separated according to varied quality, that the person in charge of carrying out this activity verifies that banana bunches are entirely free from defects such as rubbing, field damage, latex stains, sunburn, lesions caused by insects or birds, etc. They also verify that they comply with size and thickness specifications; once these criteria have been reviewed, they proceed to cut the banana bunches according to the number of fruits they have, as specified by the buyer, ranging from 4 to 8 pieces, depending on the market for which the fruit is destined. The selector has the responsibility of obtaining the greatest number of banana bunches per stalk and that these fulfill quality requirements for the market, as well as deciding the appropriate way to cut these; any bananas that have a defect or that is left over at the time of harvest is discarded. Sometimes, entire bunches are discarded due to some aesthetic defect or because they do not meet the specified size or thickness.

Arévalo and Moreira (2002) point out that the selector must be very careful regarding the quality of the hands that he is going to prepare to be packed; these workers have the ability to separate top quality from secondary quality and, therefore, have a high degree of responsibility during the plantain cutting and packaging process. In this sense, González-Rodríguez *et al*., (2019) indicate that it is advisable that the people in charge of this activity be given prior training, in order to define an objective criterion for selection and to avoid waste.

Seasons

Regarding the seasonality of prices, SAGARPA (2003) states that the upward trend in wholesale and consumer prices of bananas occurs from February to May, while the low season in terms of prices is observed from July to December, coinciding with what has been observed in the field. There is a gap between the prices paid to the producer and the prices paid to wholesalers and retailers, due to the fact that intermediaries affect the behavior of the banana marketing chain.

Similarly, this coincides with later studies by SAGARPA (2015), which conclude that bananas are available twelve months a year, however, the months of lowest production are from January to April, so the price tends to increase at the beginning of the year, when production is at its lowest concentration.

CONCLUSIONS

According to the hypothesis established in the research, it is proven that producers have high production costs; for each peso they invest, they recover

30 cents and generate 1,250 kg of fruit waste per harvest. Due to inefficient organization on the part of producers as opposed to efficient organization on the part of independent marketers in the area, unfavorable conditions are created for producers and very favorable conditions for buyers during fruit sale negotiations, causing the price paid to producers to be lower than the cost of production at certain times of year, which is $3.19 per kilo; only 25% of the producers surveyed achieved a price higher than the average cost of production per kilo, as they have a verbal agreement with the company that buys their fruit.

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