

DOI 10.7764/ijanr.v51i3.2643

ESSAY

Supply and value chain of the dairy industry in Mexico

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Abstract

E. Vargas-Bello-Pérez, O. R. Espinoza-Sandoval, S. Rodríguez-Piñeros, and N. Ghavipanje. 2024. Supply and value chain of the dairy industry in Mexico. Int. J. Agric. Nat. Resour. 219-230. The dairy sector in Mexico serves as a pivotal aspect of the national agricultural economy, marked by a complex supply and value chain with significant economic contributions. This essay aims to bridge the research gap in supply and value chain practices within the Mexican dairy industry, highlighting the need for the adoption of effective and competitive supply chain strategies to ensure food safety and security and align with export market standards. The supply chain spans several crucial stages, such as milk collection, processing, packaging, distribution, and retail. While the sector holds vast potential, small-scale farmers frequently encounter barriers to market entry and struggle with limited market access. Addressing the key elements of the supply chain and value chain within the Mexican dairy industry is imperative for devising competitive strategies and enhancing food security to comply with international export standards. The industry is confronted with sustainability challenges, notably the dearth of environment-specific data and the slow pace of technology adoption, which are aggravated by the dominance of small-scale operations, infrastructural inadequacies, and the lack of supportive governmental policies. An integrated and holistic approach is crucial for enhancing the competitiveness of the Mexican dairy industry.

Keywords: Dairy sector, Mexico, supply chain, sustainability, value chain.

Highlights

- The Mexican dairy sector has inadequate infrastructure and a lack of personnel training.

- The Mexican dairy sector has a scarcity of support programs aimed at enhancing farm profitability and efficiency.
- An integrated approach to the supply and value chain can improve the competitiveness of the Mexican dairy industry.

Introduction

Globally, the dairy industry is one of the fastest-growing industries, with the valuation nearly doubling every five years (Nagpure et al., 2023; Kumar et al., 2022). The industry is projected to be valued at 1032 billion USD in 2024, up from 673.8 billion USD in 2019 (Chevalier, 2024). Global milk output reached 965.7 million tons in 2023, with a projection of 1% growth by 2024 (FAO, 2024). In Latin America, milk production reached 20 million tons in 2023, representing an annual growth of 1.3%, primarily driven by Mexico, which contributes approximately 70% of the regional milk output (FAO, 2024). Milk production in Mexico was 13.46 million metric tons in 2022, which will surpass 14 million metric tons by 2032 (GAIN, 2022). The Mexican dairy industry, valued at 23 billion USD, provides 600,000 direct jobs and 1 million indirect jobs each year. There are over 154,000 dairy farms in Mexico, characterized by specialized cattle breeds and dual-purpose livestock. Approximately 97% of these farms consist of herds with fewer than 100 animals (INEGI, 2022).

The dairy industry covers the production of dairy products, machinery, and processing techniques within the sector, which comprises the most significant portion of the food supply chain (Zimmerman et al., 2020). This industry provides consumers with essential products such as milk, butter, and cheese, while also supplying ingredients used in processed foods, including milk powder and condensed milk (Zimmerman et al., 2020). Hence, the intricacy of the dairy supply and value chain is evident through its extensive network of diverse stakeholders and the multifaceted process of product transformation (Varavallo et al., 2022). The dairy sector is of considerable economic importance within the global food system. Although inherent vulnerabilities in the supply chain have led to the inadequate implementation of climate change mitigation strategies. Nevertheless, these weaknesses harbor the potential for positive transformation, particularly in the

creation of sustainable dairy products that meet consumer demands (Montgomery et al., 2020). It has been well documented that a sustainable supply and value chain framework for dairy farming operations is vital to effectively address the upcoming social, economic, and environmental challenges, thereby fostering long-term sustainability (Shamsuddoha et al., 2023). This essay aims to bridge the research gap in supply and value chain practices within the Mexican dairy industry by highlighting the need to adopt effective, competitive supply chain strategies to ensure food safety and security and align with export market standards. In the following sections, we introduce these concepts and discuss the current situation and future perspective of the Mexican dairy supply and value chain.

Dairy supply and value chain

Supply and value chains are terms usually used interchangeably. Although they seem similar, these two concepts differ in meaning and function. The term 'supply chain' refers to an overarching concept that encompasses the procedure, production, and delivery of products in response to customer demand (Mor et al., 2018). The dairy supply chain is a network of suppliers, manufacturers, distributors, and retailers that are involved in sourcing raw materials, creating the product, and selling it to the consumer (Malik et al., 2022). Carranza et al. (2007) present an example of how the milk value chain works in Mexico. Generally, the supply chain involves multiple stages depending on the product to be manufactured, but in general, the stages are as follows: (1) Acquisitions: Supply of raw materials or components from producers and suppliers; (2) Manufacturing: Convert raw materials into finished products; (3) Distribution: Deliver finished products to retailers; and (4) Customer service: Help customers experience a convenient purchase (Lu, 2011).

The term 'value chain' was coined by Michael Porter, a professor at Harvard Business School, in

his 1985 book “Competitive Advantage: Creating and Sustaining Superior Performance” (Porter, 1985). He defined the value chain as the lens through which companies discover how to produce products that offer customers greater value than the intrinsic work they do. The value chain is defined as a series of activities that a company undertakes to design, produce, and deliver valuable products or services to its customers (Figure 1). Value chains aim to increase value throughout the buyer’s journey while reducing overhead. When the supply chain focuses on the operational side (flow of materials and products), the value chain prioritizes the added value of products while creating and delivering products or services (Dubey et al., 2020). The value chain typically involves the following stages: (1) Research and development (R&D): develop innovative strategies, improve existing products, and design new ones; (2) Design: optimize product designs to meet customer preferences; (3) Production: implement sustainable production strategies that benefit companies, consumers, and the environment; (4) Sales and marketing: effectively deliver the key messages and values of the product/service to potential customers for better sales; (5) Cus-

tomers service: support and assist customers with efficient purchases; and (6) After-sales support: foster long-term customer relationships, increase customer lifetime value, and enhance customer retention (Walters & Helman, 2023).

As defined at the beginning, the supply and value chains are different yet interrelated and complementary concepts. A supply chain encompasses the entire scope of activities, from the sourcing of raw materials to the delivery of finished products to the end consumer (Hugos, 2024). Conversely, the value chain signifies the sequence of business operations aimed at augmenting the utility of a firm’s goods and services, thereby increasing customer value. Essentially, the supply chain describes the interconnected processes that encompass raw material production through the final product reaching the consumer. The value chain highlights the array of activities centered on the enhancement of a product (Feller et al., 2006). Together, these two networks are instrumental in delivering high-quality products to customers at competitive prices. The supply chain and value chain are often considered in tandem due to their interconnected nature (Kaplinksky & Morris,



Figure 1. The Value Chain Scheme as proposed by Michael Porter.

2003). Without a resilient supply chain, the value chain will not function effectively. With an inefficient value chain, the supply chain will produce suboptimal products that fail to satisfy customer needs and wants (Feller et al., 2006). The supply chain is a subset of a company's value chain. The value chain includes processes beyond primary activities, such as operations and logistics in and out of the supply chain. These additional processes include sustainability measures, sales, marketing, support, company infrastructure, etc. In value chain thinking, a company motivates suppliers to deliver just-in-time, optimizing inventory, mitigating overstocks and shortages, and reducing the burden of inventory management (Zamora, 2016). Several strategies merge value and supply chains, to offer value to customers and growth to the company (Walters & Helman, 2023), among them are as follows:

Manufacturing and production: Adding value at this stage of the supply chain aims to reduce the cost of the product and, at the same time, improve the quality of the product (Kemitare et al., 2021). This may include investing in technology, leveraging data, and automation. This will help speed up the process and improve quality control. Value chain thinking could also lead to a production process that enables the development of sustainable products, such as sustainable packaging and the use of recycled raw materials (Herrera et al., 2023).

Outbound logistics: Value addition in outbound logistics aims to ensure that products reach customers quickly and efficiently. This would include optimizing shipping routes, last-mile deliveries, introducing strategic warehouses/ fulfillment centers, contracting and outsourcing, collaborating with brick-and-mortar stores, and even digital deliveries (Rajahonka & Bask, 2016). A supply chain is a network of companies and individuals who perform activities to develop and deliver goods and services to customers. The value chain focuses on optimizing these

processes to add value to these products and services. To increase profitability, companies need to have strong global value chains in which supply chains operate efficiently (Lu, 2011; Walters & Helman, 2023).

Differences between supply and value chains

There are several fundamental distinctions between the supply chain and value chain, as outlined below (Hughes et al., 2014; Ricciotti, 2020; Dubey et al., 2020):

- Supply chain refers to the comprehensive integration of activities, entities, and businesses involved in the movement of a product from its origin to the consumer. In contrast, value chain comprises a series of activities that incrementally increase the value of a product at every stage until it reaches the end consumer.
- The supply chain concept has its roots in the field of operational management, whereas the value chain comes from the domain of business management.
- Supply chain activities are primarily concerned with the physical logistics and transportation of materials. In contrast, the value chain focuses on value addition to a product or service to increase customer value.
- The supply chain commences with the procurement of raw materials and concludes with the product's delivery to the customer. The value chain starts with the customer's order and ends with the product.
- The foremost goal of the supply chain is to achieve total customer gratification, whereas the value chain aims to increase product value.

Stages of the milk and its derivatives supply chain

Raw materials

The raw materials for milk production are mainly composed of forage and grains. Farmers often produce their forage, supplementing it with purchased materials when necessary. The main forages used include alfalfa hay, silage corn, wheat silage, silage or fresh triticale, and silage or fresh ryegrass (SIAP, 2020; Herrera, 2023). To produce these forages, farmers require inputs such as fertilizers, water, seeds, land, machinery, and fossil fuels. Grains, which typically account for 50% of dairy cows' rations, are often sourced from external suppliers. In Mexico, much of the corn is produced in the Mennonite region of Cuauhtémoc, whereas the rest must be imported from the "Corn Belt" regions of the USA, highlighting Mexico's reliance on external grain supplies. Other components, such as soybeans, are also commonly imported. The prices of these inputs are dictated by the Chicago Stock Exchange, where market prices are determined. In Quintero Herrera's study (2023), an example of how the supply chain of a specific region can be evaluated is presented.

Production and storage

The second stage in the chain is production, where the forage and grains are transformed into milk through the lactation of cows of different breeds; in Mexico, the predominant breed is the Holstein (Ramírez-Rivera et al., 2019). In Figure 1, the inputs and outputs of the milk production system are illustrated. Though not the primary output of the system, meat is also produced due to the sale of low-production animals. Another important output of the system is greenhouse gas (GHG) emissions, as well as manure, which typically reintegrates into cropland. Once milk is produced, it undergoes a series of processes, as depicted in Figure 2, where rapid cooling

technologies are used to cool the milk to 4 °C, to minimize bacterial growth (Saucedo-Velázquez et al., 2023).

Transportation

On the farm, milk is typically stored for no more than 24 hours before being collected by the buyer and transported to the industrial plant. During transportation, the milk is not cooled, and the pipes function as thermoses, maintaining the milk at approximately 4 °C, depending on the distance from the processing plant. Distances vary from 6 km to 1000 km depending on the buyer. This transportation process incurs substantial costs for the producer, which are largely dependent on the distance traveled. To facilitate transportation, food-grade pipes are typically rented from a transportation service provider. This stage of the supply chain has a considerable carbon footprint (Losada et al., 2001; Gómez et al., 2023; Herrera, 2023).

Processing

Upon arrival at the plant, the raw milk is unloaded and cooled to 2 °C, after which it is passed through purifiers or filters to remove large particles. The next step is skimming, a process that separates the solids from the raw milk, resulting in the production of cream, butter, as well as skim milk. The skimmed milk then undergoes various processes, such as pasteurization, ultra-pasteurization, or drying to produce milk powder (SIAP, 2020).

The specific processes employed can vary between production plants, as each facility often has its own patented processes and proprietary formulas, which are typically kept confidential. Although milk is the primary product, the plant also produces other value-added products, such as cheese and yogurt among others (Dobson & Jesse, 2009).

Packaging

Packaging is the process of placing a product in a sterile and sealed container that enables it to reach consumers safely. This process typically uses plastic containers, which have been criticized for the contamination they can cause (Herrera, 2023). In this sense, Tetra Pak-type containers have been proposed as a potentially less contaminating alternative (Mink, 2013). The production of these containers is often outsourced to third-party suppliers, although some companies opt to manufacture their containers.

Storage

Storage is a critical process, as the requirements for dairy products vary significantly. Some products, such as milk powder, do not require a cold chain, making their storage relatively straightforward and cost-effective. In contrast, products like pasteurized milk or fresh milk necessitate a constant cold chain due to their short shelf life. Other products, such as cheeses, have

longer shelf-lives and can be stored for extended periods (SIAP, 2020).

Point of sales

Once the industrialization and packaging processes are completed, the products are transported to various points of sale, ranging from supermarket chains to small retail stores. At these points of sale, the cold chain must typically be maintained for dairy products that require refrigeration. The effectiveness of the sales point is directly correlated with product sales, with higher-end sales points often resulting in better sales performance (Jiménez-Jiménez et al., 2011).

Final consumer

The consumer is the central axis of all decisions, and understanding their behavior is crucial for redirecting the industry (Rogers-Montoya, 2024). However, consumer preferences are dynamic and influenced by various factors, including geo-

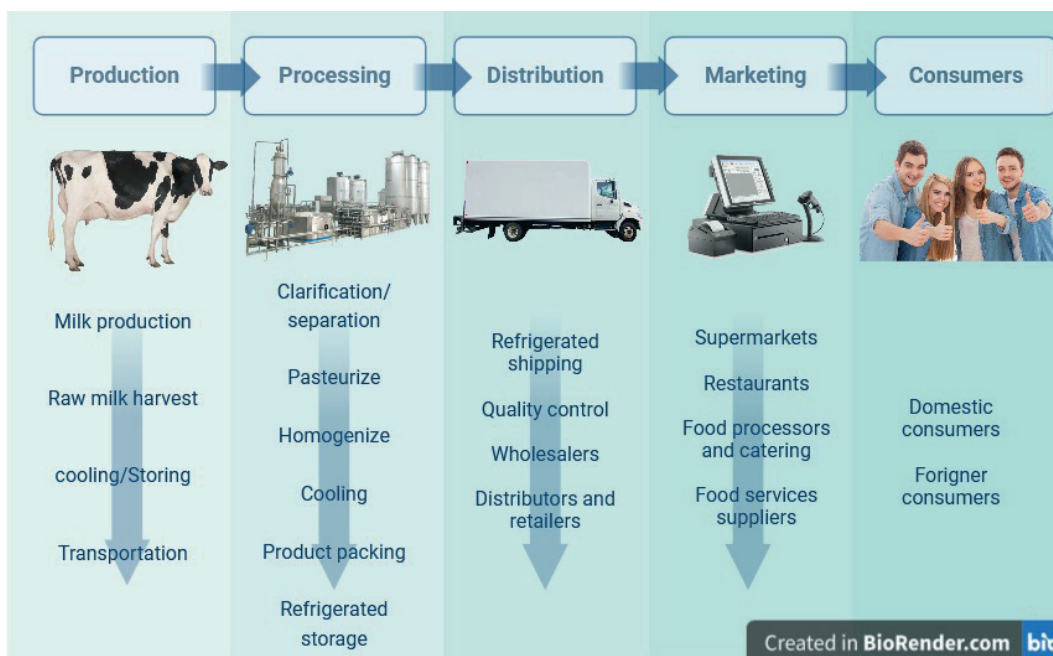


Figure 2. A simplified dairy supply chain in Mexico.

graphical location and age demographics, which can change over time. As a result, companies continually study consumer behavior to adapt their products to meet the evolving needs of their target market and tailor their marketing campaigns to effectively reach and engage with consumers (Tanyeri-Abur & Rosson, 1997; Hernández et al., 2000; Rogers-Montoya, 2024).

Value chain in the dairy sector

The value chain, also known as value chain analysis, is a strategic management concept introduced by Porter (1985). This concept has been widely applied in various works to evaluate the value chain of a specific company or region. In the dairy sector, several studies have employed this approach, including Cavazos González (2022), who used it to assess the Mennonite cheese production region. Another example is the study by Losada et al. (2000), which examined the milk market in Mexico City. The stages of the analysis are as follows:

Support activities: These auxiliary activities facilitate and enhance primary activities while also supporting each other. Their main objective is to augment the efficiency of primary activities and amplify the overall value-creation process.

- **Company Infrastructure:** At the farm level, this involves ensuring that farmers possess the necessary resources and support to optimize production, including access to training and compliance with relevant legal regulations (Hernández et al., 2000).
 - **Human resources management:** These activities are highly developed, as high-level training is required throughout the entire supply chain, from farms to the industrial level, to ensure that all personnel meet international standards and possess the necessary qualifications (Losada et al., 2000).
 - **Technology development:** This process involves the creation of innovative products, such as high-protein milk, milk with bioactive compounds, or milk with additional health benefits, which can provide a competitive edge in the market (Hernández et al., 2000; Hernandez, 2013).
 - **Purchases:** At the farm level, for example, the continuous acquisition of modern and less polluting machinery, as well as the procurement of environmentally friendly inputs, adds value to the farm's operations (Dobson & Jesse, 2009; SIAP, 2020).
- Primary activities: These activities are directly involved in the production of the product and are crucial for transforming inputs into outputs.
- **Inbound logistics:** At the farm level, this includes the supervision of feeding programs, management programs, and staff training. At the industrial level, it involves the receipt and handling of raw milk at the plant (Dobson & Jesse, 2009).
 - **Operations:** These include dairy cooling and processing plants, where the focus is on ensuring certification and compliance with health regulations (SIAP, 2020).
 - **Outbound logistics:** In the case of milk, storage is a persistent challenge because of the need to maintain a cold chain for most products, which helps minimize contamination. Larger distribution units, for instance, can add value to this step by ensuring efficient and effective logistics. Additionally, green logistics can also contribute to this process (Kemitare et al., 2021).
 - **Marketing and sales:** This stage of the chain is crucial, as it enables dairy companies to inform consumers about the origin and benefits of their products, among other key

aspects. In Mexico, most dairy companies have comprehensive marketing programs that allow them to effectively reach and engage with consumers (Rogers-Montoya, 2024).

- **Services:** In the dairy industry, this stage is centered on providing customer service through contact lines, where consumers can report concerns, seek support, and receive assistance (Herrera, 2023; Maldonado-Siman et al., 2013).

Conclusion and final remarks

This essay aims to bridge the research gap in supply and value chain practices within the Mexican dairy industry, highlighting the need

for the adoption of effective, competitive supply chain strategies to ensure food safety and security and align with export market standards. Overall, analyses of value and supply chains are essential for understanding the functioning of the Mexican dairy industry, as well as for optimizing business. Small companies would benefit from the implementation of these techniques to increase their competitiveness in an already high demand market. Several strategies exist within the Mexican dairy supply chain to transition toward sustainable systems. However, significant hurdles impede progress, such as insufficient data for environmental modeling and limited local capacity for implementing new technologies. Challenges in the dairy sector include a predominance of small farms (96% with fewer than 100 cows), inadequate infrastructure, a

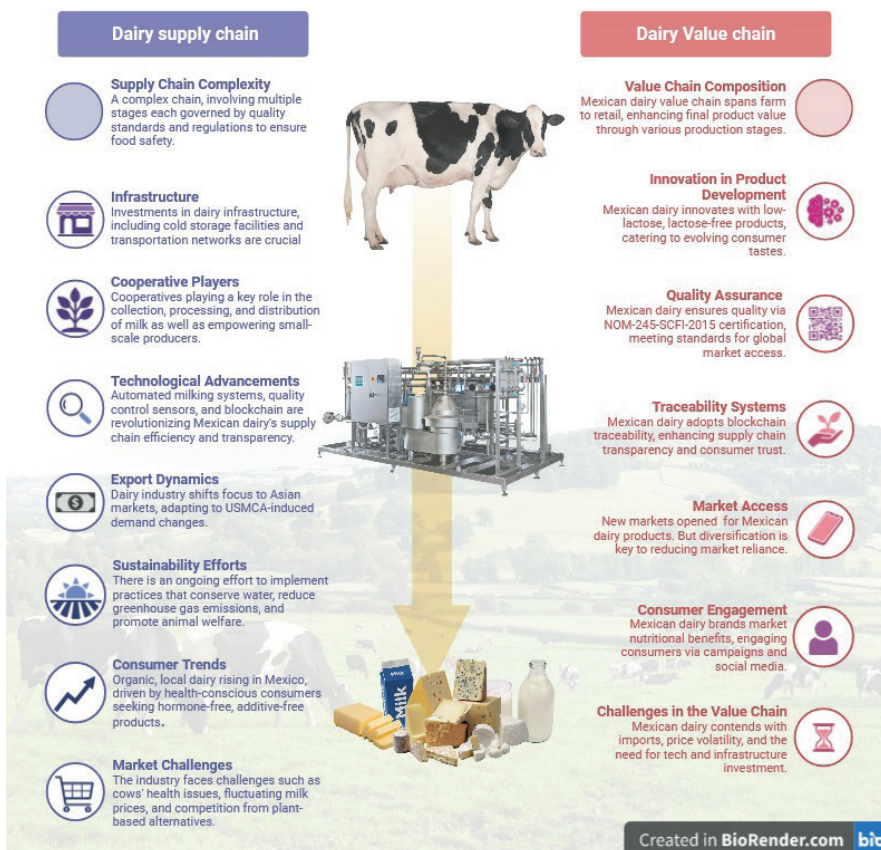


Figure 3. Dairy supply and value chain in Mexico.

lack of training, limited participation in value addition, price volatility for raw milk without regulatory mechanisms, and a scarcity of support programs aimed at enhancing farm profitability and efficiency. Despite a gradual decline in inflation rates, the entire dairy chain in Mexico remains impacted. There is a pressing need for a substantial overhaul in Mexico's dairy policy to bolster both milk production and the consumption of dairy goods. An integrated approach to the supply and value chain, coupled with superior decision-making, can substantially enhance the competitiveness of the Mexican dairy industry.

Ethics statement

The authors declare that no animals were used.

Data availability statement

Not applicable.

Conflict of interest statement

The authors declare that there are no potential conflicts of interest.

Author contributions

All the authors substantially contributed to the conception, design, analysis, and interpretation of the data; checked and approved the final version of the manuscript; and agreed to be accountable for its contents.

Funding

None.

Resumen

E. Vargas-Bello-Pérez, O. R. Espinoza-Sandoval, S. Rodríguez-Piñeros, y N. Ghavipanje. 2024. Cadena de suministro y valor de la industria láctea en México. Int. J. Agric. Nat. Resour. 219-230. El sector lácteo en México es un aspecto fundamental de la economía agrícola nacional, caracterizado por una cadena de suministro y valor compleja con importantes contribuciones económicas. Este ensayo tiene como objetivo cerrar la brecha de investigación en las prácticas de suministro y cadena de valor dentro de la industria láctea mexicana, destacando la necesidad de adoptar estrategias de cadena de suministro efectivas y competitivas para garantizar la seguridad alimentaria y alinearse con los estándares del mercado de exportación. La cadena de suministro abarca varias etapas cruciales, como la recolección de leche, el procesamiento, el envasado, la distribución y la venta minorista. Si bien el sector tiene un gran potencial, los pequeños agricultores con frecuencia encuentran barreras para ingresar al mercado y luchan con un acceso limitado al mismo. Abordar los elementos clave de la cadena de suministro y la cadena de valor dentro de la industria láctea mexicana es imperativo para diseñar estrategias competitivas y mejorar la seguridad alimentaria para cumplir con los estándares internacionales de exportación. La industria se enfrenta a desafíos de sostenibilidad, en particular la escasez de datos específicos sobre el medio ambiente y el lento ritmo de adopción de tecnología, que se ven agravados por el predominio de operaciones de pequeña escala, deficiencias de infraestructura y la falta de políticas gubernamentales de apoyo. Un enfoque integrado y holístico es crucial para mejorar la competitividad de la industria láctea mexicana.

Palabras clave: cadena de suministro, cadena de valor, México, Sector lácteo, sostenibilidad.

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