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# Development of processes for the distribution system of the tomato cold supply chain

# Desarrollo de procesos para el sistema de distribución de la cadena de suministro de tomate en frío

PORTUGAL-VÁSQUEZ, Javier†*, LAGARDA-LEYVA, Ernesto Alonso, GARCIA-CUEVAS, Ana María and VEGA-TELLES, Ernesto Alonso

*Instituto Tecnológico de Sonora. Departamento de Ingeniería Industrial*

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ID 1sr Author: *Javier, Portugal-Vásquez* / **ORC ID:** 0000-0002-8986-2023, **CVU CONAHCYT ID:** 249136

ID 1st Co-author: *Ernesto Alonso, Lagarda-Leyva* / **ORC ID:** 0000-0001-9552-9908, **CVU CONAHCYT ID:** 433524

ID 2nd Co-author: *Ana María, García-Cuevas* / **ORC ID:** 0009-0002-7557-9486

ID 3rd Co-author: *Ernesto Alonso, Vega-Telles* / **ORC ID**: 0000-0002-8260-3002, **CVU CONAHCYT ID:** 1179288

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**Abstract**

This research project aims to propose a technological solution to the problems faced by the tomato cold chain; Based on different investigations, it was found that the problems that should be paid more attention to are within the processes of storage, transport and customer service. The research question of the project was: What are the best logistics practices in the storage, transport and customer service of the tomato cold chain in the Southern region of Sonora? the objective: to develop the best logistics practices in storage, transport and customer service of the tomato cold chain in the southern region of Sonora in order to improve the operational efficiency of organizations. To meet the objective, a methodological route was generated where different regulations are identified to establish a dashboard of key performance indicators. As main results, the objectives and the most important key processes to be carried out in the cold distribution process were found according to different authors, the procedures for each process (storage, transport and customer service) were established, in the same way a control board was generated with key performance indicators according to each key process.

**Cold supply chain, Processes, Efficiency**

**Resumen**

El presente proyecto de investigación tiene como finalidad plantear una solución tecnológica a los problemas que enfrenta la cadena de frío del tomate; basándose dentro de diferentes investigaciones se encontró que los problemas a los que se les debe de poner más atención están dentro de los procesos de almacenamiento, transporte y servicio al cliente. La pregunta de investigación del proyecto fue: ¿Cuáles son las mejores prácticas logísticas en el almacenamiento, transporte y servicio al cliente de la cadena de frío del tomate en la región Sur de Sonora?, el objetivo: desarrollar las mejores prácticas logísticas en almacenamiento, transporte y servicio al cliente de la cadena de frío del tomate en la región sur de Sonora con el fin de mejorar la eficiencia operativa de las organizaciones. Para cumplir con el objetivo se generó una ruta metodológica donde se empieza por identificar diferentes normativas hasta establecer un tablero de mando de los indicadores claves de desempeño. Como principales resultados se encontraron los objetivos y los procesos clave más importantes que hay que llevar a cabo en el proceso distribución en frío de acuerdo a diferentes autores, se establecieron los procedimientos para cada proceso (almacenamiento, transporte y servicio al cliente), de igual manera se generó un tablero de control con indicadores clave de desempeño de acuerdo a cada proceso clave.

**Cadena de sumintros fría, Procesos, Eficiencia**

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*Correspondence to Author (E-mail: javier.portugal@itson.edu.mx)
† Researcher contributing first author.

## Introduction

In the logistics of perishable products, the cold chain is a key concept. This is why this project will focus on providing solutions to the distribution system of the tomato supply chain of companies in southern Sonora; this implies a challenge in food supply, with optimal processes in post-harvest, handling and transport, as well as strict controls in the management of the cold chain of products that require temperature control and thus meet the food needs, all because the development of information technologies have forced companies to make logistics management more efficient to maintain and improve their competitiveness. The role of logistics is traditionally focused on placing the right products, in the right place, at the right time and in the desired conditions, contributing as much as possible to the profitability of a firm. But nowadays, logistics is conceived at a much broader level where the aim is to achieve a synchronised interaction between all those involved in logistics activities. An interaction in which time, space and movements are reduced and thus achieve better products and higher profits for the final consumers (E-logistics, 2019).

Logistics and supply chain is the set of approaches used to efficiently integrate suppliers, warehouses and shops, so that products are produced and distributed in the right quantities, in the right places and at the right time, in order to minimise total costs, satisfying the required service levels (Soto, 2010). For the distribution of perishable products, trying to always maintain their quality and safety from the moment it leaves the point of origin, the cold chain is used, which aims to maintain the characteristics of the product until it reaches the end customer. The application of cold is one of the most widespread methods of preservation and is applicable to the food, health and pharmaceutical industries. This method is based on lowering temperatures to inhibit the growth and proliferation of microorganisms and altering agents totally or partially (Zavaleta, 2012). To achieve an ideal cold chain, specialised refrigeration facilities and temperature-regulated transports are required. Maintaining it is fundamental for food safety and therefore all stages of the process must preserve it with great care. If we refer to the conservation temperature, there are two types of cold chain: refrigeration and freezing (Bernad, 2017).

Avoiding breaking the cold chain is one of the main obligations of the logistics manager. According to Mecalux (2019), within the different tasks that comprise the logistics supply chain, the phases that increase the probability of breaking the cold chain are in the warehouse and transport; if the cold chain is broken, this can generate problems such as: The premature deterioration of the goods, The loss of organoleptic properties such as taste and/or appearance, The proliferation of bacteria and microorganisms harmful to humans that reproduce more easily in relatively temperate environments, among others.

According to a study conducted by the GCCA in 2014, it was concluded that the needs and problems for cold chain management are common in the region, problems such as: There are not enough cold chain distribution centres, There is no supply of specialised refrigerated transport, There is a need to improve the implementation and enforcement of food safety regulations, The cold chain for fruits and vegetables is weak, There are no good practices in transport companies and retailers for the proper handling of products that require refrigeration, There is a lack of implementation of good energy efficiency practices to make costs more competitive in refrigeration services, There is a need to strengthen technical training, training for processors, wholesalers and all members of the chain to improve cold chain operations.

Improving food conditions, making use of technologies to freeze and refrigerate food are indispensable tools to ensure food safety, as well as the use of appropriate packaging to prolong and preserve food in storage and transport.

The trends in cold logistics are marked by the challenges facing logistics in general, including market globalisation, cost reduction along the cold chain, strategic integration with the rest of the supply chain activities and maximising the use of capacity and resources. Given this reality, logistics providers with cold chain services must develop strategies that allow them to stay at the forefront of the industry (Solistica, 2018). Also an important point to take into account are the trends in the supply chain according to COVID-19. The coronavirus pandemic brought disruptions to the supply chain, changes in consumption patterns and a need for companies to react and adapt quickly. (Chavez, 2021).

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Agriculture is one of the most important economic activities globally for its contribution to food production and job creation, and agricultural production promotes the emergence and development of agro-industries (Da Silva and Baker, 2013). Globally, the most important agricultural products are cereals, followed by vegetables and fruits. Potatoes and tomatoes contribute 50% of the world's production, so their value is of paramount importance in the global food system. In Mexico, as in other parts of the world, fresh tomatoes are mainly consumed; however, they are also processed industrially for the production of pastas, sauces, purees and juices, among other products.

The red tomato is one of the most important horticultural products in Mexico due to the value of its production and the labour demand it generates, being the main horticultural product for export; in tomato cultivation, techniques have been implemented such as the irrigation sheet that works as a simulator, where climatic data, soil type, irrigation, crop cycle and automatically the program provides information on balances or growth are introduced (Morales, 2017).

The cold chain system offers agricultural producers a logistics and service platform that contributes to reducing the high percentage of losses in the production and marketing stages of perishable fresh produce. In addition, it promotes food safety and improves food quality (Ibidem, p7).

Temperature control is an essential element for the survival of perishable products. In this case, for tomatoes, appropriate cooling is between 8 and 12ºC and it is advisable to apply it quickly after harvesting. The shelf life of the produce, closely related to the state of ripeness at harvesting, is a few days at 20ºC and one to two weeks at 8 or 12ºC. Any uncontrolled exposure to lower temperatures (below 8ºC) or very high temperatures (30ºC), especially in the sun, penalise the quality and the conservation of the produce. For red tomatoes, cold tolerance is recommended at 8ºC (Moras, 2021).

According to the Panorama Agroalimentario (2020), the tomato is considered the number one vegetable, it is a bilocular, subspherical, globular, highly coloured berry, typically with yellowish to red tones due to the presence of the pigments lycopene and carotene. It has a slightly sour taste. It is generally round and flattened in shape, except for some varieties with elongated fruit, such as the saladette. Although they are of different sizes, it is generally a large fruit. China leads the world tomato harvest, its volume (61.5 million tonnes per year) is equivalent to that of the following five producing nations; Table 1 shows each country's production in tonnes of tomato.

| Position | Country | Production (tonnes) |
|---|---|---|
| 1 | China | 56,423,811 |
| 2 | India | 18,399,000 |
| 3 | United States of America | 13,038,410 |
| 4 | Turkey | 12,600,000 |
| 5 | Egypt | 7,943,285 |
| 6 | Italy | 6,437,572 |
| 7 | Iran | 6,372,633 |
| 8 | Spain | 4,671,807 |
| 9 | Brazil | 4,167,629 |
| **10** | Mexico | **4,047,171** |

**Table 1** Countries by World Tomato Production
*Source: Adapted from Atlas Big (2021)*

Mexico ranks tenth in the world ranking of tomato production; three out of every hundred kilograms of the vegetable produced in the world originate from Mexican fields: it is grown to meet domestic and export demand. Foreign demand for Mexican tomatoes is recorded every month, although due to the seasonal effect on national production and demand from the United States (Mexico's main client), between August and September there is a slight drop in volume. Among the vegetables exported by Mexico, tomato is the most important due to the economic benefit it represents for farmers and traders, with sales of just over 1,690,000 tonnes per year. Adapted from Panorama Agroalimentario (2020).

The tomato supply chain is one of the most important in Mexico, since thanks to tomato cultivation, tomatoes are the third most exported product in the country, making Mexico the world's leading exporter with 1.5 million tonnes per year, 50% of the country's total production (Infoagro, 2019); the tomato supply chain is made up of a series of interrelated links, considering primary activities, see Figure 1:

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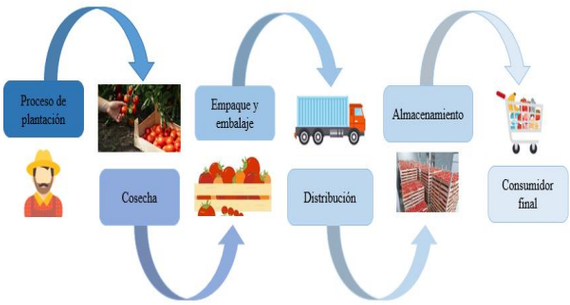


**Figure 1** Tomato Supply Chain
*Source: Own elaboration adapted from (Consejo Nacional de Productores de Tomate, A.C., 2012)*

In order to better understand the situation of the tomato supply chain, a SWOT analysis is carried out, identifying the internal and external characteristics that are divided into Strengths, Weaknesses, Opportunities and Threats.

STRENGTHS:

1. Important supply chain, due to the value of its production and demand.
2. Main horticultural export product.
3. Development of strategies to stay ahead of the cold chain.
4. Increasing demand.
5. Tomato represents great economic importance for growers and traders.
6. Year-round tomato production.

OPPORTUNITIES:

1. emergence and development of agro-industries.
2. New techniques in tomato cultivation.
3. Exploiting demand.
4. Satisfying the needs for the product in question.
5. Reducing costs along the cold chain.
6. Maximising the use of capacity and resources.

DEBILITIES

1. Poor business logistics culture.
2. Inadequate cold chain conditions.
3. Inadequate staff training.
4. Major problems in warehousing and transport; probability of breaking the cold chain.

AMENAZES

1. Breaking the cold chain and therefore facing different problems.
2. Changes in consumption patterns.
3. Trends according to COVID-19.

**Problem statement**

The tomato cold chain must be maintained throughout the supply chain, from the moment the shipper sends the product until it is delivered to the client or end user. Therefore, the storage, transfer and distribution of the product must be guaranteed so that it does not lose its properties during storage and transport.

In Mexico, tomato is the most important crop due to the economic benefits it represents for farmers and traders, as it is the most important vegetable in production and is distributed throughout the country; however, the most important production area is the northwest. The objective of the cold chain is not to break down during the whole supply chain, as it involves many problems related to transport, storage, packing and packaging, and the care of regulations and good manufacturing practices. For this reason, a cause-effect diagram is made to identify all the possible causes behind the inefficiency in cold chain logistics operations, see Figure 2.

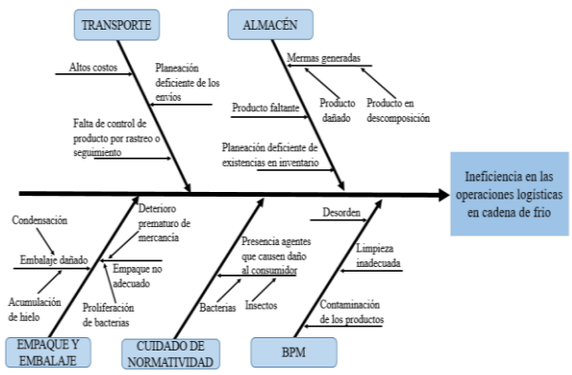


**Figure 2** Cause-Effect Diagram
*Source: Own elaboration*

In Figure 2, the causes can be identified by different blocks that are divided into transport, warehouse, packing and packaging, regulatory care and good manufacturing practices; since all of these categories are where there are problems that possibly cause inefficiency in logistics operations in the cold chain.

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Mexico has had a higher logistical growth compared to other developing countries, but even so, there are many challenges and areas for improvement in the cold chain distribution process in both the industrial and commercial sectors, especially in SMEs, whose main concern is to take care of product shelf life.

According to the growth that Mexico has presented, added to the extreme climate of the southern region of Sonora, companies are forced to strategically control all their cold processes, especially in storage and distribution.

Due to all of the above, it is necessary to find a solution to improve logistical efficiency and place the product under the customer's conditions, making the most of the flexibility of the resources available.

Therefore, after analysing all the problems that are generated, the question posed for this research is the following: *What are the best logistical practices in storage, transport and customer service in the tomato cold chain in the southern region of Sonora?*

Objective: *To develop the best logistics practices in storage, distribution and customer service in the tomato cold chain in the southern region of Sonora in order to improve the operational efficiency of the organisations.*

The first benefit of the project is to have duly standardised processes and procedures that comply with the different national and international standards, since in Mexico there are regulations for the storage and distribution of perishable products that need to be chilled or frozen, which require strict compliance, and as a result efficient logistics operations can be generated in the cold chain. The preservation of product quality throughout the logistics chain is an important condition, which will bring benefits, the fact that the product managed in the cold chain is not handled correctly in a given time, will have to go through a process of destruction or loss which leads to break the cold chain, which is what we want to avoid.

Having processes and procedures in place will help to reduce the operational costs of the distribution system, particularly transport, storage and handling costs.

The costs in a cold chain are geared towards maintaining the freshness of the products so that they reach the final consumer in the right condition and fit for consumption.

The direct beneficiaries of the results of the project are all those companies involved in cold distribution systems in relation to the product in question, which is tomatoes, since providing solutions to control the cold distribution system improves the capacity to react and respond, reduces costs, increases the satisfaction of end consumers, improves or implements the traceability of products and deliveries, reduces the handling of products and optimises distribution.

If this project is not carried out, the companies in southern Sonora will continue to operate under the same conditions, which in some cases is inefficient in cold chain logistics operations, generating losses for the companies, both in terms of products and resources, which generates high operating costs and non-compliance with the levels of service and quality provided to the client.

## Theoretical foundation

### *Supply chain*

It is a set of functional activities (transport, inventory control, etc.) that are repeated many times along the flow channel, through which raw materials are converted into finished products and value is added for the consumer. Since raw material sources, factories and points of sale are usually not located in the same places and the flow channel represents a sequence of manufacturing steps, logistics activities are repeated many times before a product reaches its market place (Ballou, 2004). According to Roldan (2017), the supply chain's main objective is to satisfy the needs of the end customer in the best possible way. This includes the following purposes: Delivering goods and services on time, Avoiding unnecessary losses or wastage, Optimising distribution times, Proper management of inventories and warehouses, Establishing adequate communication and coordination channels, Coping with unforeseen changes in demand, supply or other conditions.

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*Logistics*

Logistics is the process of strategically managing the acquisition, movement and storage of materials, parts and finished inventory (and the corresponding information flow) throughout the organisation and its marketing channels, so that current and future profitability is maximised through cost-efficient order processing. (Melero, 2018)

The logistics chain is made up of all those processes involved directly or indirectly in the action of satisfying customer needs. The phases considered key are the following: Supply, Production, Storage, Distribution and Customer Service.

*Cold chain*

The cold chain is a set of logistical measures to guarantee a constant temperature and other parameters necessary for the correct maintenance of products throughout their transfer from production to the consumer (Pérez, 2021).

It is so called because it is composed of different stages. If any of the points of the cold chain were to be broken or altered, the whole chain would be affected, damaging the quality and safety of the product, facilitating microbial growth, both of spoilage microorganisms and disease-producing pathogens, and the alteration of the food by degrading enzymatic reactions causing undesirable organoleptic characteristics. In the case of having a cold chain that is kept intact during production, transport, storage and sale, the consumer is guaranteed that the product he/she receives has been kept in a safe temperature range in which micro-organisms, especially the most harmful to health if any, have stopped their activity. In addition, an appropriate storage temperature will preserve the organoleptic and nutritional characteristics of the food. Temperature is a critical factor in food production and distribution systems that must be rigorously controlled. Three fundamental stages are involved in the cold chain: Storage in cold rooms or warehouses at the production centre, transport in special vehicles with temperature recording, distribution platform and sales centres.

A determining factor to be taken into account is that if the cold chain is broken in any of its phases, the product must be discarded, since if it is chilled or frozen again, the damage will already be done and we could expose the end consumers to a high risk. In addition to changes and deterioration in the texture, taste or smell of the products, their nutritional properties could also be affected. The most dangerous aspect of breaking the cold chain process is the exposure to food poisoning due to the ingestion of bacteria growing on the products themselves. If the cold chain is broken, even for a short period of time, bacterial nuclei can be reactivated, so that when the food is refrozen, it is already full of bacteria and toxins that can cause food poisoning (Cofrico, 2021).

The importance of the cold chain lies mainly in considering the losses of food products caused by inadequate handling, storage and transport (Nieto, 2014).

*SCOR Model*

According to the Supply Chain Council (2012) the SCOR model has been developed to describe the business activities associated with all phases of meeting customer demand. The model itself contains several sections and is organised around the six main management processes of Planning, Sourcing, Production, Distribution, Return and Enablement. By describing supply chains using these process building blocks, the model can be used to describe supply chains that are either very simple or very complex using a common set of definitions. As a result, industries can be linked to describe the depth and breadth of virtually any supply chain.

The model is designed to support supply chain analysis at multiple levels.

*Performance indicators*

A management indicator, or performance indicator, is a way of measuring whether an organisation, unit, project or individual is achieving its strategic goals and objectives. KPIs provide the most meaningful performance information that allows organisations to understand whether or not the organisation is on track towards defined goals. In this way, well-designed performance indicators are vital navigational tools, providing a clear picture of current performance levels and whether the company is where it should be.

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At the organisational level, the most effective management indicators are closely linked to strategic objectives and help answer fundamental business questions. Therefore, a good starting point is to identify the questions that decision-makers, managers or external stakeholders need to answer. One or two key performance questions should be identified for each strategic objective (Roncancio,2018).

**Methodology to be developed**

Identify regulations applicable to the tomato cold distribution process. The Mexican Official Standards (NOM), Mexican Standards (NMX) and ISO standards applicable to tomato cold chain distribution, good cold chain practices, cold transport requirements, tomato packaging and packing requirements were identified, resulting in a list of standards and requirements applicable to cold chain distribution.

Establish the objectives of the cold distribution system. A bibliographic research of different authors on the cold distribution system was carried out, the most mentioned objectives were taken to be able to carry out the design of the technological solution, as a result, a table was obtained with the objectives of the cold distribution system most cited on the different authors.

*Identify key processes in cold distribution*

After establishing the objectives of the cold distribution system, a theoretical research was carried out on different authors, who mention the most important key processes in cold chain distribution. As a result, a list of key processes was made on the most cited authors associated with the different contributions of the key processes of cold distribution, ranging from storage to distribution and handling.

*Establishing cold distribution procedures*

Based on previous research, the most important procedures for carrying out cold chain distribution, such as storage, distribution and handling, were established. As a result, a cross-functional diagram of the key processes in the cold chain was drawn up, based on the Deming cycle (PHVA) with the aim of establishing continuous improvement.

*Establish a dashboard of key performance indicators*

In this step, the key performance indicators of the storage, distribution and handling processes were defined, based on Kaplan and Norton's (2009) scorecard (BSC), in order to measure the performance of these processes. As a result, a scorecard was obtained, which mentions the processes, the indicator, the target, the periodicity, the formula and the person responsible for carrying out the activity.

**Results**

*Identify the regulations applicable to the tomato cold distribution process*

Research was carried out on the Mexican Official Standards (NOM), Mexican Standards (NMX) and ISO standards applicable to the cold chain distribution of tomatoes, good manufacturing practices in the cold chain, requirements for cold transport, packaging and packing requirements for tomatoes, and a list of standards and requirements that were met in the process of cold chain distribution of tomatoes was drawn up, see Table 2.

| NORMA | DESCRIPTION |
|---|---|
| NMX-FF-031-1997-SCFI. | Non-industrialised foodstuffs for human consumption - fresh vegetables - tomato |
| NOM-FF-54-1982. | Non-industrialised foodstuffs for human consumption - fresh vegetables - tomatoes in shell. |
| NOM-EM-039-FITO-2002 | Mexican official standard with emergency character, establishing the requirements for the registration to the program of induction, application and certification of good agricultural and handling practices for the production and packing of fresh tomato for export. |
| NOM-251-SSA1-2009 | Characteristics and specifications for assigning and confirming expiry/reanalysis periods, holding times for bulk food or intermediate food products stored during processing and establishing the necessary storage and transport conditions. |
| NOM-030-SCFI-2006 | Commercial declaration on the label - Specifications. |
| NOM-050-SCFI-2004 | Trade information - General provisions for products. |
| NMX-EE-59-1979 | Packaging - symbols for handling, transport and storage. |
| NMX-EE-98-1980 | Packaging - Shock test. |
| ISO 3864: 1984 | Safety colours and safety signs. |
| ISO 6780:2003 | Pallets for intercontinental material handling - main dimensions and tolerances. |
| ISO 3676:2012 | Packaging - unit load size - dimensions. |
| ISO 3394: 2019 | Tertiary packaging dimensions |
| NMX-FF-031-1997-SCFI. | Non-industrialised foodstuffs for human consumption - fresh vegetables - tomatoes. |

**Table 2** Standards Applicable to the Tomato Cold Chain Packing and Packaging Distribution System
*Source: Own elaboration (2021)*

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*Good manufacturing practices in cold chain distribution*

This point presents a list of good manufacturing practices of the distribution of the cold chain for tomato, mentioning what should be done and why it should be done; it should be kept in mind that the control of the chain starts from harvesting, through processing and packaging, transportation and storage, to the point of sale and the place where the final customer consumes the products.

What to do:

- The cold chain should never be interrupted.
- Food requiring refrigeration should be transported in insulated or refrigerated vehicles.
- Maintain temperature control.
- The transport temperature should be between 0°C and 7°C for refrigerated products and -18°C or lower for frozen products.
- Loading and unloading should be done quickly and the vehicle should be parked as close to the car park as possible.

Why it should be done:

- If the cold chain is interrupted the temperature can rise and allow rapid and progressive reproduction of micro-organisms.
- All dirt in transport vehicles must be removed to avoid sources of further contamination of the food.
- Low temperatures ensure proper preservation of food during transport.
- Slow loading and unloading and keeping the doors open allows for cold losses and temperature increase inside the vehicle body.

*Establishing the objectives of the cold distribution system*

Bibliographic research was carried out according to different authors on the most important objectives, according to their criteria, which should be applied to the cold distribution process. As a result, a list of different authors with objectives of the cold distribution system was obtained. See table 3.

| AUTHORS | OBJECTIVES |
|---|---|
| Juan Carlos Hernández, Juan Pablo Antún y Angélica Lozano (2013) | - Reduction of inventories through a system of hierarchical distribution centres and satellite cross-docking to meet customer service levels.<br>- Development of innovative alternatives for order processing and customer service.<br>- Batch order processing and limiting delivery spraying in e-commerce.<br>- Development of reverse logistics processes and operations to meet the requirements of recycling standards and public policies.<br>- Introduction of IT innovations in logistics.<br>- Innovation in vehicle technology.<br>- Outsourcing of operations through logistics operators with dedicated fleets.<br>- Preference for the location of supports in logistics centres. |
| Centro Europeo de Empresas Innovadoras Valencia (2008) | - Reduce delivery times<br>- Reduce transport costs<br>- Establish an efficient reverse logistics system<br>- Optimal utilisation of transport space (full load) |
| Universidad Nacional Abierta y a Distancia (2015) | - The product reaches consumers in good condition.<br>- Cold transport must guarantee speed, safety and adaptability.<br>- Storage and transport information and communication technologies for logistical operations<br>- Cold chain temperature |
| Publicaciones Vértice (2008) | - Maximise customer service levels<br>- Minimising distribution costs<br>- Preserving products through good materials handling<br>- Reducing delivery times |
| Revista Logistec (2012) | - Improve service levels to customers. |

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| | |
|---|---|
| | - Providing added value to customers through transport and distribution services.<br>- Rationalisation of distribution networks.<br>- Exploring shared services.<br>- Reducing distribution cycle time. |
| Ferrell y Hartline (2011) | - Ensure product availability<br>- Reduce distribution costs<br>- Reduce delivery times<br>- Increase customer satisfaction |
| Pelayo (2008) | - Product reaches the consumer safely.<br>- Transport in special vehicles<br>- Storage in chambers or cold stores at the production site.<br>- Loading and unloading time during transport |
| Lhermie, Miquel y Parra (2008) | - Cover the entire target market<br>- Minimise distribution costs<br>- Adding customer service and reverse logistics to the product<br>- Control and coordinate distribution activities in relation to marketing programme |

**Table 3** Objectives of cold distribution according to different authors
*Source: Own elaboration (2021)*

The objectives that presented the highest frequency according to the authors cited above were: reduce delivery times and total compliance with deadlines, reduce transport costs, improve customer service, meet the needs of consumers, with these objectives will be the scope that will help to define the guidelines for the design of the technological solution.

*Identify key processes of cold distribution*

Once the objectives, goals and actions of the cold distribution system had been defined, a bibliographic research was carried out to obtain the most important key processes in cold chain distribution. According to Hurtado (2020), the key processes are those that allow value to be offered to customers to satisfy their needs; where the activities involved and their adequate performance are vital for the business. Table 4 was drawn up with the contributions of the different authors:

| AUTOR | KEY PROCESSES |
|---|---|
| Mosquera López (2016) | - Storage<br>- Transport<br>- Packing and crating<br>- Exporting<br>- Information technology<br>- Logistics operators |
| Ariza D. (2015) | - Supply<br>- Distribution<br>- Storage<br>- Transport |
| Juárez C. (2021) | - Storage<br>- Transport<br>- Logistics traceability<br>- Material handling<br>- Cold chain control |
| Garcia Garcia (2020) | - Distribution<br>- Management<br>- Human resources<br>- Service |
| Procolombia (2014) | - Measurement<br>- Temperature control<br>- Storage<br>- Packing and packaging<br>- Transport<br>- Information technology<br>- Legal regulation<br>- Training and information |
| García D. ECOMED (2019) | - Warehousing<br>- Material handling<br>- Transport |
| Velasco, A. (2020) | - Storage<br>- Transport<br>- Transport<br>- Customer service |

**Table 4** Key processes of cold distribution according to different authors
*Source: Own elaboration (2021)*

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In table 16 it can be seen that, according to the contributions of each author, the most important ones that are the most repeated are storage, transport and customer service; due to this, these will be the processes that will be taken into account to later analyse their procedures and design the technological solution.

*Storage*

Storage is the key to control the logistics process, which consists of the provisional accumulation of stocks, from the proper care of the products to the organisation of their transfer to the points of sale or production (Liat Faena, 2021). The processes involved in warehousing are as shown in Figure 3.


**Figure 3** Processes covered by storage
*Source: Own elaboration (2021)*

*Transport*

Transport is the operational area of logistics that moves and geographically positions the inventory. Transport is part of logistics, where, together with means and methods, it allows goods to be taken from one place to another (Pérez and Gardey, 2021). The processes covered by transport are as shown in Figure 4.


**Figure 4** Processes involved in transport
*Source: Own elaboration (2021)*

**Customer service**

According to Corrales (2019), customer service encompasses all those strategies, activities and processes aimed at satisfying the needs of the users; it is the movement of the finished product to the customers. In this area, shipment to the customer's location represents the final destination. Through the customer service process, the timely and geographic location of inventory becomes an integral part of marketing. The processes encompassed by customer service are as shown in Figure 5:


**Figure 5** Transport processes
*Source: Own elaboration (2021)*

*Establishing cold distribution procedures*

Based on the research on the contribution of the different authors mentioned in the previous point, the procedures to carry out the distribution in the cold chain are established. In the next step of the results, each of the key processes was broken down on the basis of the Deming Cycle (PHVA). Figures 6, 7 and 8 below show these key processes (storage, transport and customer service), represented as Figures in the Deming Cycle containing the PHVA steps of continuous improvement.

*Warehousing*

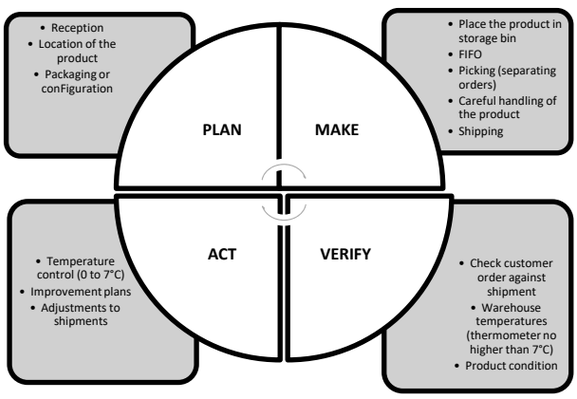


**Figure 6** Activities Key Storage Proces
*Source: Own elaboration (2021)*

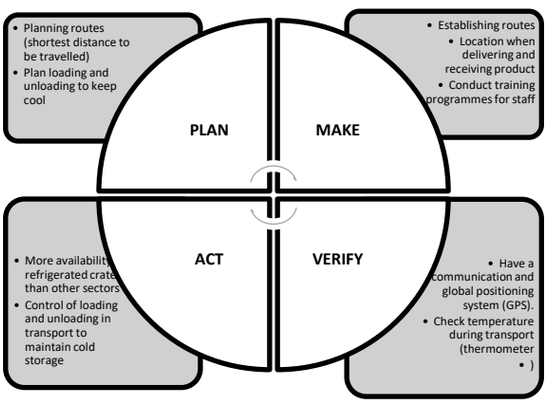


**Figure 7** Activities of the Transport Key Process.
*Source: Own elaboration (2021)*

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*Customer service*

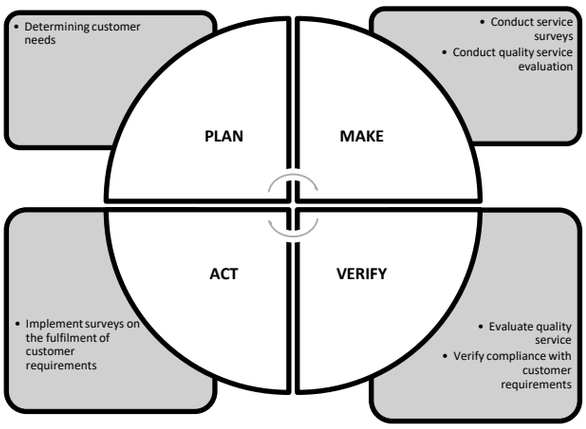


**Figure 8** Activities of the Customer Service Key Process
*Source: Own elaboration (2021)*

*Establish cold distribution procedures*

Once the procedures and activities of the storage process based on the PHVA cycle had been established, a cross-functional diagram of the process was drawn up, showing the procedures and different necessary activities that interact as a whole, with the aim of setting out how the storage process would be carried out and establishing who is responsible for each procedure. See Figure 9.

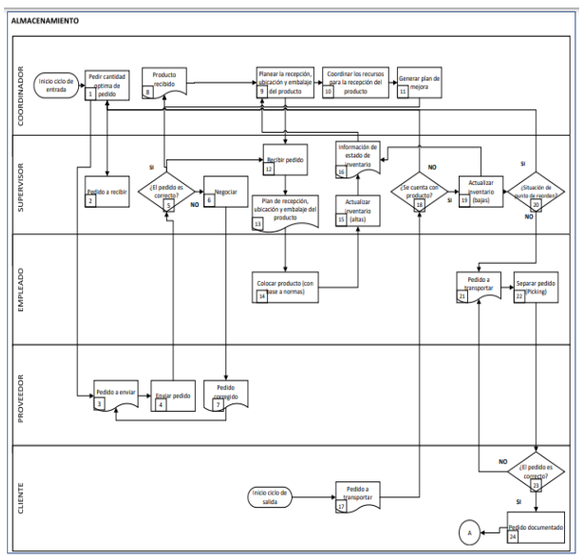


**Figure 9** Cross-functional diagram of the cold storage process
*Source: Own elaboration (2021)*

Cross-functional diagram of the transport and customer service process

The cross-functional diagram of the transport and customer service processes is shown below, with the procedures and activities established in the PHVA cycle, establishing who is responsible for each procedure.

It should be noted that the transport and customer service processes were merged as their activities are related. See Figure 10.

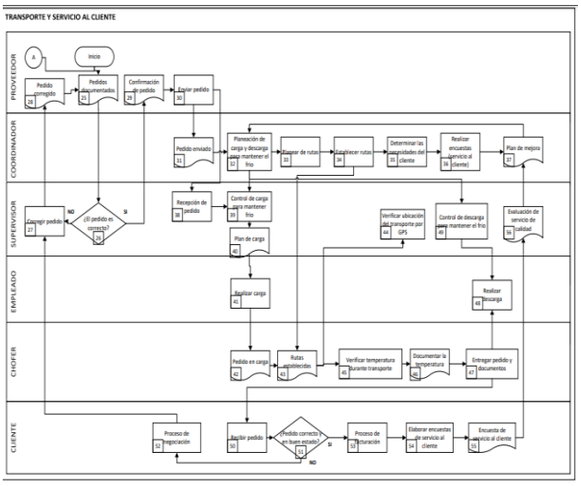


Figure 10 Cross Functional Diagram of the Transport and Customer Service Process
*Source: Own elaboration (2021)*

*Establish a dashboard of key performance indicators*

Table 5 below is a dashboard of key indicators for the different processes of warehousing, transport and customer service. The control panel is aimed at obtaining results that have an impact on the objectives, goals and actions, in order to be closer to the goals set and to identify opportunities for improvement.

| PROCESS | INDICATOR | GOAL | PERIOD | PERFORMANCE | | | RESPONSIBLE |
|---|---|---|---|---|---|---|---|
| ALMACENAMIENTO | COST PER SQUARE METRE | The lowest possible cost | Weekly | | | | Warehouse Coordinator |
| | PERCENTAGE OF WAREHOUSE UTILISATION | Use the most available warehouse space | Monthly | | | | Warehouse Coordinator |
| | PERCENTAGE VOLUME OF INCOMING PRODUCT. | Receive the highest quantity of expected product | Weekly | | | | Warehouse Coordinator and Warehouse Supervisor |
| | PERCENTAGE OF COMPLETED ORDERS | Place the highest percentage of completed orders | Daily | | | | Warehouse Coordinator and Warehouse Supervisor |
| | PERCENTAGE OF INCORRECTLY PLACED PRODUCT | Place the most product correctly | Weekly | | | | Warehouse Coordinator |
| | PERCENTAGE OF ERRORS DUE TO VOLUME RECEPTION | Minimise receiving errors | Weekly | | | | Warehouse Coordinator |
| | PERCENTAGE OF COMPLIANCE WITH COLD AND FROZEN TEMPERATURES | Meet ideal warehouse temperature | Daily | | | | Warehouse Coordinator |
| TRANSPORTE | CAPACITY UTILISATION | Maximum utilisation of transport capacity | Monthly | | | | Distribution Manager |
| | TRANSPORT ASSET UTILISATION | Increased utilisation of available transports | Monthly | | | | Distribution manager |
| | CORRECT DELIVERIES | Achieve the highest number of correct deliveries | Weekly | | | | Distribution Manager |
| | ON-TIME DELIVERIES | Achieve highest number of on-time deliveries | Weekly | | | | Distribution Manager |
| | DELIVERY TIME | Achieve shorter delivery times | Weekly | | | | Distribution manager |
| | COST PER KILOMETRE | Control of distance travelled versus total transport cost | Monthly | | | | Distribution manager |
| | FUEL USAGE PER KILOMETRE | Control fuel usage | Weekly | | | | Distribution Manager |
| SERVICIO AL CLIENTE | LEVEL OF CUSTOMER DELIVERY PERFORMANCE | Achieve the highest level of customer delivery performance | Daily | | | | Customer Service Supervisor |
| | RATE OF RETURN | Lower number of returns | Daily | | | | Customer Service Supervisor |
| | NUMBER OF COMPLAINTS RECEIVED | No claims | Weekly | | | | Customer Service Supervisor |

**Table 5** Key indicator dashboard for the cold distribution system *Source: Own elaboration (2021)*

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Using the above indicators is of vital importance to measure the activity and locate the areas of improvement of each of the different processes, the application of these mainly influences costs and customer satisfaction which is also a process that has indicators. Such is the importance of all indicators that if they are not applied, there is no possibility to improve and achieve better efficiency.

## Conclusions

The proper application of logistics is of great importance for the performance of any company, as this and previous research has shown. In order to achieve the design of the solutions, a methodology that includes seven steps was followed and therefore conclusions will be presented for each step.

In the first step, the regulations, good manufacturing practices and requirements applicable to the tomato cold chain distribution process were identified, and this step was the fundamental one for the following six remaining steps.

The second step of the method consisted of establishing the strategic objectives, where various authors were consulted and gave their opinion on which were the most important objectives, and the four most frequently mentioned were established, which were: reducing delivery times and total compliance with deadlines, reducing transport costs, improving customer service and satisfying the needs of consumers. One of the advantages of carrying out this step was that by having enough information, it was possible to select these objectives and thus help define the guidelines for the design of the technological solution.

In the third step, once the strategic objectives were established, the key processes were established. As in the previous step, different authors were consulted and the most important key processes were identified, which were warehousing, transport and customer service.

In the fourth step, procedures were generated for each of the key processes, giving them a logical order using the structure of the Deming Cycle (PHVA). Cross-functional diagrams were created for each process (including the two procedures of transport and customer service in one), specifying who is responsible for carrying out each activity in each process, as well as the required documentation. This step was the most time-consuming due to the creation of the diagrams.

Finally, in the fifth step of the method, the key performance indicator (KPI) dashboard was established based on the Kaplan and Norton (2009) scorecard (BSC), which contains the storage, transport and customer service processes, the indicator to be reviewed, the expected goal, review frequency, the formula for each indicator and the person responsible for carrying it out; This also includes the traffic lights to indicate the percentage of compliance of the company and what percentage it should be, this helps to inform about the real situation that is presented and also to motivate the teams responsible for the fulfilment of these objectives reflected and thus constantly progress.

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