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# HACCP OPERATION IN TWO LATIN AMERICAN MEAT PACKERS: CASE STUDY

**Nury M. Guerrero-Castiblanco, Ema Maldonado-Simán*, Pedro A. Martínez-Hernández**
[1]Chapingo Autonomous University, Texcoco, México

**Keywords:** *meat exporters, food safety, Latin American packers, HACCP*

***Abstract***
*The hazard analysis and critical control point (HACCP) system is a protocol aimed to guarantee food safety, especially in companies dedicated to meat processing. Companies in food international trade are subjected to intense inspection and verification processes, and international standard certifications have become a key factor in global trade. The purpose of this study was a comparative analysis of HACCP certification in the Mexican and Chilean meat packers that send meat to international markets by a field inspection of each to identify opportunities for improvement. International trade standards along with packers' expectations and needs to be fulfilled to attain a place in world markets were bases for this study. Guidelines for field inspection came from the HACCP protocol. Field data were derived from 15 indicators — five intrinsic to the HACCP plan and ten external. The Chilean packer was superior to the Mexican packer in terms of many indicators. Thus, the first one had a chance for a better position in international markets than the latter. It was concluded that the HACCP audit is an excellent tool to measure the suitability of meat packers in achieving a place as a supplier and remaining in the international food trade.*

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## Introduction

Food safety is a constant concern worldwide. Human health institutions and governments are constantly looking for the most appropriate forms of supervision throughout the entire food production chain. It presents the provision of varying quality management tools that emphasize product standardization [1]. The HACCP system has a worldwide recognition as a preventive system for food safety. It is based on measuring hazards, estimating risks, and establishing specific control measures aimed to prevent and control. Shuvo et al. [2] indicated that its implementation by the food industry enables it not only to produce safe food but also to demonstrate how food safety issues are designed and applied objectively and transparently. HACCP is a tool with a systematic approach that is based on the application of specific science to each of the reported hazards to achieve food safety.

According to Borodin et al. [3], for a food business to be competitive and remain in the market, it is necessary to monitor hazards and control critical parameters determined at each stage of production. In the case of companies dedicated to meat products, this monitoring must also be carried out from raw materials and auxiliary materials up to the final product. De Oliveira et al. [1] stated that some prerequisites, such as Good Manufacturing Practices (GMPs) and Sanitation Standard Operating Procedures (SSOPs), should be established before HACCP implementation and operation. Their function is to keep hazards in the facility under control, whereas HACCP focuses on managing specific hazards within processes. In the meat industry, the application of GMPs and SSOPs impacts the production of safe and high-quality products. Therefore, the strict application of these regulatory guidelines at all stages guarantees the production of meat products that meet the quality levels required by consumers [4]. Another factor of interest refers to the hygiene and habits of employees to avoid contamination of products, which can only be achieved through Good Hygiene Practices (GHPs) and training as a fundamental part of an integrated program [5]. ADAFSA [6] mentioned that promoting GMPs and achieving them require auditing processes throughout the supply chain. Audits report risks that are still present whether in facilities, equipment, or work areas.

The meat industry has undergone substantial changes in recent years due to the development of new technologies in various areas, such as primary production, slaughtering, dressing, and meat processing [7]. The OECD/FAO [8] indicated that production is expected to increase 16% by 2025 because of increased meat demand in developing countries due to economic growth, increased consumer purchasing power, and increased knowledge of food composition and properties. Consequently, production is focused on the main challenges in meat safety that are related to traditional hazards, as well as new or emerging ones. It is equally important to identify food safety objectives based on risk assessment in the production and processing of meat and systematic food management as proposed by the HACCP system [9].

As a result, inspection has a relevant role in the control of safety. In European countries, modernization is being applied both for the improvement of livestock health and processing. The notable change is that nowadays a risk-based inspection is used, which is in line with a safety assurance system. Factors such as existing trade agreements with third countries, costs involved in the inspection process, inadequate food chain information, and the reluctance of inspectors have formed a wall of obstacles to be faced. Improvement of the components is necessary for the modernization of inspection systems to be achieved, thereby reducing the workload [10]. Laukkanen-Ninios et al. [11] pointed out the importance of continuous meat inspection based on scientific and practical reasons, taking into account the scientific point of view and risk management. For this reason, a case study was proposed to address HACCP certification in the Mexican and Chilean meat packers, in order to define opportunities for improvement.

## Objects and methods

Field research was set as a case study of HACCP system implementation in two meat packers, one located in Mexico and the other in Chile. The study of these two packers was based on the proposal put forward by Flyvbjerg [12], based on a global context with the expectations and needs of the companies and under the requirement to place their products in international markets [13]. First, the main guidelines for the identification of the characteristics present in HACCP were identified [14], and prior to the study, the relevant requests were made to the management of each of the companies. The management information was collected during on-site stays for 43 and 14 days at the Mexican (ME) and Chilean (CE) meat packers, respectively, in 2018. Information gathered came from 15 indicators (Table 1) — five inherent in and ten external to the HACCP plan; the last ones had the potential to influence HACCP performance.

**Table 1. Indicators inherent in and external to HACCP evaluated in the Mexican and Chilean meat packers**

| |
|---|
| *Indicators inherent in the HACCP plan* |
| Process flow diagram |
| Product description |
| CCP identification |
| CCP monitoring |
| Verification of the system |
| *Indicators external to the HACCP plan* |
| System certification |
| Integrated management systems annexes |
| Legal authorizations |
| Current authorized in-process and export markets |
| Personnel age and education level |
| Sanitary performance standards |
| Prerequisites |
| Suppliers |
| Official inspection |
| Geographical conditions |

## Results and discussion

### *Indicators inherent in the HACCP plan*

*Meat packers' descriptions*

General characteristics of each meat packer are shown in Table 2. The ME was under the Federal Inspection Type (TIF) certification, National Service for Agri-Food Health, Safety and Quality (Servicio Nacional de Sanidad, Inocuidad y Calidad Agroalimentaria [SENASICA]). This certification guarantees strict quality and hygiene standards in plants, and thus the production of safe and high-quality products suitable for national and international markets. Activities are carried out in cattle slaughter, cutting, boning and vacuum packing. Around 98% of cattle slaughtered come from production units certified by Mexican federal authorities. The meat industry represents a link between consumers and agriculture and, therefore, requires an exhaustive analysis of the population's requirements and adjustment to raw materials of the stipulated quality [3]. Consequently, the implementation of HACCP represents an advantage in the whole phase of the production chain of meat products [15].

**Table 2. General characteristics of the Mexican and Chilean meat packers**

| Characteristics | Mexican packer (ME) | Chilean packer (CE) |
|---|---|---|
| Altitude (masl) | 60[1] | 5,72[2] |
| Average annual temperature (°C) | 31.7[1] | 14.1[2] |
| Species slaughtered | Bovine | Swine |
| Certifications | Federal Inspection Type (TIF) | L.B. O'Higgins |
| Installed capacity (animals/shift) | 400 | 2,000 |
| Hours per shift | 8 | 8 |
| Cutting and boning rooms | 1 | 1 |
| Freezing capacity (t) | 42 | 40 |
| Refrigeration capacity (t) | 450 | 160 |
| Pallet store | 1 | 1 |
| Export quantities (t yr$^{-1}$) | 6,461.5 | 1,500 |
| Fresh marketing (%) | 80.7 | 0 |
| Frozen marketing (%) | 19.3 | 100 |
| Accredited animal suppliers (%) | 98 | 100 |
| Number of employees | 443 | 272 |

[1] [16] [2] [17]

The CE operation authorization came from the Health Service, L.B. O'Higgins, Warehouse-type storage: frozen food, refrigerated food by Regional Ministerial Health Secretariat (Secretarías Regionales Ministeriales de Salud SEREMI Salud) L.B. O'Higgins, and Agricultural and Livestock Service, L.B. O'Higgins.

Swine slaughtered come from farms certified by the agency Animal Production Units Program under Official Certification (Programa de Planteles Animales bajo Certificación Oficial [PABCO]), with compliance of the National Plan supervised by the Agriculture and Livestock Service (Servicio Agrícola Ganadero [SAG]), and the Chilean Trade Association of Swine Producers (Asociación Gremial de Productores de Cerdos de Chile [ASPROCER]), subjected to the official standards to monitor dioxins, furans and dL-PCB. The CE carries out swine slaughter and boning activities. The HACCP is certified, according to the requirements of the Recommended International Code of Practice, General Principles of Food Hygiene. Additionally, it places on the market refrigerated offal, bone-in and boneless by-products chilled and frozen. As stipulated in the HACCP concept, three stages in its design focus on evaluating the CCPs of any unacceptable risks. Finally, the identified control parameters are applied and followed up for prevention and reduction to acceptable levels [18].

*Process flow*

As indicated by Allata et al. [19], the operability of HACCP stands on seven principles aimed at maintaining control at acceptable levels of the identified hazards through the process flow chart. Then, the case study shows the primary and secondary activities of the process in the flow chart of both companies (Table 3). A sequential and unidirectional process flow was identified with on-site verification of the diagram as proposed by USDA [20]. Differences can be identified between the enterprises in terms of the design method and the mechanism used in the integration of raw materials. The ME applied a separate flow between the main flow diagram and the viscera flow diagram. However, both diagrams were operated under the same vertical format, in which the flow of operations was applied from top to bottom in an ordered list of process operations. In contrast, the CE used a single panoramic format, where both flows were processed together. It was presented in a single format, which can be viewed more accurately and quickly, thus facilitating operation. In addition, it presents both vertical and horizontal line recording and the various activities.

In both packers, the figures in the flowchart design were used correctly. However, there were differences between them, as the ME did not have different and precise pictogram in the description of the start and end activities in the flowchart. With this procedure, both companies claimed that the use of these diagrams led to better control of the relevant inputs and also facilitated the auditor in the interpretation. The ME flowchart had alternative diagrams in raw materials with a more significant number of structures and decision steps. However, the process of using abrasive chemicals for viscera blanching and leg peeling was not described.

The HACCP team was in charge of checking the flow diagrams on-site in order to make this management activity efficient. In this concept, it is indispensable to prepare the flow chart properly and ensure that it is thoroughly analyzed in the field, acquiring all the fundamental information. Therefore, having a flowchart with a structure that includes the required informative planning and detailed analysis leads to an integrated production process, which serves as a basis for the detection of possible deviations [21].

*Product description*

According to Pombo Marques [21], the authority of the HACCP team is represented by the team leader. The objective of this representative is to ensure the proper functioning of the HACCP plan. The leader's duties also include detailed monitoring to ensure compliance with legal criteria, reviewing all phases of the plan, attending to responsibilities and coordinating internal and external operations. In accordance with the HACCP plan of the packers of the study case, the team members carried out a concise and summarized description of the meat products. Table 4 shows the characteristics of both packers. The ME included chemical characteristics in greater detail, such as percentage of moisture, protein, fat and ash, while the CE omitted these elements. However, the latter fully described scalding by immersion and manual flaming. Although the ME performed spray sanitization, the description was

**Table 3. Comparative flow chart of the Mexican and Chilean meat packers**

| Characteristics | Mexican diagram | | | | Chilean diagram |
|---|---|---|---|---|---|
| | Process flow | | Viscera flow | | Complete flow |
| Main activities | 41 | | 16 | | 35 |
| Secondary activities | 11 | | 3 | | 16 |
| Decision stages | 10 | | 9 | | 4 |
| CCPs identified | 3 | | 1 | | 2 |
| *Alternate Input Diagrams* | | | | | |
| Number of times | 2 | | 1 | | 1 |
| Input | Water | Sanitizers | Chemicals | Packaging | Inks |
| Activities | 2 | 4 | 6 | 3 | 4 |
| Decision stages | 2 | 2 | 3 | 1 | 0 |

Table 4. Comparative description of the products in the Mexican and Chilean packers.

| Descriptive factors | | Mexican enterprise (ME) | Chilean enterprise (CE) |
|---|---|---|---|
| Product family | | Carcass meat | Rods |
| Components and ingredients | | ➢ Beef carcasses include the following tissues: muscle (the main one), connective, cartilaginous and adipose.<br>➢ Meat product, 100% beef. | ➢ Swine carcasses may include tail, pillars, peripheral portion of the diaphragm, head, kidneys, feet and hide.<br>➢ By-products include heart, liver, kidneys, thymus, udder, blood, tongue, brain or fat of slaughter species; lungs are excepted from this category (RSA*, Title XI, paragraph I, article 269). |
| Packaging | | No type of packaging is used for beef carcasses. | No type of carcass packaging is used |
| Shelf life (days) | | 7 | 12 |
| Microbiological characteristics | | ➢ *E. coli* O157: H7 in 25 g — Absence<br>➢ *Salmonella* spp. in 25 g — Absence | The microbiological criteria established in accordance with national and international standards are stipulated in document FC-DC-HACCP-01- Plant Sampling Program. |
| Chemical composition (%) | | Moisture 60 to 80 | The description does not contain this type of information. |
| | | Protein 16 to 25 | |
| | | Fat 2 to 10 | |
| | | Ash 1 | |
| Organoleptic characteristics | Texture | It does not have this type of information | Firm and taut, elastic when raw and succulent when cooked. |
| | Odor | It does not have this type of information | Typical to slightly acidic pork. Without inappropriate odors (ammoniac or others). |
| | Color | It does not have this type of information | Pale pink, there may be variations in color in the same cut in the different muscles due to the amount of myoglobin with colors ranging from very pale pink to intense pink without representing alterations or pathologies in the quality of the meat. |
| Physicochemical characteristics | | pH 5.5–6.5, $a_w$ 0.99 | Meat carcass pH 5.7–6.2, $a_w$ = 0.985<br>Viscera pH 7, $a_w$ = 0.985 |
| Intended uses | Type of consumer | General public and industrial processes | General public |
| | Distribution conditions | Refrigerated (maximum 4 °C), clean vehicle, free of pests and in good physical condition. | The pork rods are cooled and then shipped by means of trucks conditioned with refrigeration equipment to maintain temperatures ≤ 7 °C. |
| | Sales locations | To distributors of meat in carcasses, cut and boned in the same establishment. | To distributors and points of sale, where they can be industrially roasted, or distributed nationwide, such as supermarkets or artisan butcher shops. |
| | Preparation methods | The consumer debones, cuts and cooks the product before consumption. | It is eaten cooked. |
| | Sensitive population | There is no sensitive population. | There is no sensitive population. |
| | Allergen declaration | No allergens are present in the finished product. | No allergens are present in the finished product. |
| Types of products | | Beef in carcasses | Swine in carcasses |
| Storage and shipping temperature | | The description provided does not include this type of information. | Rods: ≤ 7 °C (art 271) |
| | | | Fresh cuts: ≤ 7 °C (art 271) |
| | | | Fresh by-products: ≤ 3 °C (GB/T 20094–2006) |
| | | | Finished product: –2 to 2 °C. |
| Processes with microbicidal/ microbiostatic effect | | The description provided does not include this type of information. | Scalding by immersion at 60 °C, manual flaming. |

* Chilean Health Regulations for Food Products.
pH — Hydrogen potential.
$a_w$ — Water activity in food.

not considered relevant, which is not in line with USDA recommendations [20]. The CE performed and described processes with microbicides and microstatics in blanching, while at the ME, the details of this information were not considered relevant.

*Identification and monitoring of Critical Control Points (CCPs)*

For the identification of CCPs, both packers applied the same methodology, which was based on the following activities: 1) establishment of criteria for hazard assessment; 2) identification of hazards; 3) identification of preventive measures; 4) identification of significant hazards; 5) hazard analysis; and 6) determination of CCPs using a decision tree. The CE HACCP team strictly applied the criteria of the Chilean Standard (NCh) 2861 of 2011, which interpretation is more feasible to the system auditor, and provides more reliable legal support. On the contrary, the ME evidenced no type of reference, which leads to more difficulty in its interpretation. Regarding the identification of hazards and preventive measures, both packers made similar procedure tables, where the possible hazards and the preventive measures implemented to prevent, eliminate or reduce the risk to an acceptable level were identified for each stage.

The identification of significant hazards was carried out in accordance with Chilean Standard NCh 2861, which implied having the result of an analysis of possible hazards. The occurrence had to be controlled in the operation stage to ensure safety. In the case of the ME, the procedure was similar but with some variants. In reference to the determination of CCPs, both companies operated the decision tree method. For each significant hazard identified, the result obtained was two CCPs for CE (Table 5), and three CCPs for ME (Table 6). Critical limits were established, and monitoring conditions were precisely specified. Both companies had a list of procedures and frequencies, at which activities were carried out in accordance with regulations [20]. ISO 22000:2018 [22] also indicates that at the end of the hazard assessment, it is necessary to select control measures, applying the CCP decision tree, in order to prevent or eliminate inherent food safety hazards and have a risk at an acceptable level.

As for good sanitary characteristics of carcasses, they are achieved by applying hygienic standards and a high level of sanitation during slaughter. Unacceptable results of microbiological analyses indicate sources of contamination and the lack of sanitary measures applied [23]. For example, a degree of fecal cross-contamination at the slaughterhouse is reflected in the prevalence of *Salmonella*-positive carcasses. Hygienic handling of the head and pluck during slaughter and dressing is of vital importance. Post-mortem inspection is necessary [24]. Besides, high counts of coliforms on carcass surfaces suggest a high incidence of fecal contamination, which means a potential risk for the consumer, and it reflects inadequate sanitation management during various activities, such as raw material handling, cleaning and sanitizing meat contact surfaces, and employee activities [25]. Most often, cross-contamination of carcasses occurs during such processing stages as skinning and evisceration as hides and the gastrointestinal tract are primary sources of pathogenic microorganisms [26]**.** Thus, strict sanitary and hygienic standards together with cold chain management must be applied in conjunction with the sanitary state of the refrigerated rooms. To minimize food safety problems, sanitary treatment of facilities is indispensable.

The cold processing step, such as rod cooling, represents an integral step in meat production, achieving stable quality and safety of these products. It is imperative to refrigerate them through a continuous cold chain in all phases of the technological process. Cold processing impacts the growth rate of microorganisms that lead to spoilage and also decreases the risk of pathogen growth [27]. Carcasses are typically cooled by circulating air in a refrigeration unit at a temperature of 0 to 4 °C, which is commonly applied in slaughterhouses for beef, pork, and other species. Initial chilling is the most important step in the cold chain to ensure appropriate food safety for carcasses [28]. According to Zhang et al. [29], rapid chilling achieves a significant reduction of bacteria on carcasses, followed by multi-step chilling. USDA-FSIS performs inspections of carcasses at all federally inspected slaughter facilities and verifies the compliance of establishments with food safety regulations [30].

*Verification of the HACCP system*

Verification is a strategy that ensures that the HACCP plan is working as intended according to the stipulated objective, methods, frequency and responsibilities. These activities generate evidence of its execution through records and documentation [31]. In the case of the CE, the HACCP team or part of it verified the system. The version of records and procedures was stipulated with three types of verification: daily, periodic and integral. The first was related to monitoring at each CCP and stipulating responsibilities and procedures. Periodic verification was carried out by the head of quality assurance with a monthly review of result records and microbiological updates of the system. Concurrently, the integral verification focused on the annual check of the operation of the entire HACCP system, which was performed by the whole team. In the ME, non-categorized verification was related, it was not systematized, and this information was not incorporated and consigned within the HACCP plan. The team met annually or whenever necessary in order to review the entire system. The categorization of the verification and frequencies included in the HACCP plan of the CE provided a comparative advantage since it provided greater clarity and organization. Critical limits were established, and monitoring conditions were precisely specified. Both companies had a list of procedures and frequencies, at which activities were carried out in accordance with regulations [20].

**Table 5. Monitoring and follow-up of critical control points according to the HACCP plan in the Chilean packer.**

| HACCP plan | CCPs | Monitoring and tracking | | | | |
|---|---|---|---|---|---|---|
| | | What | Who | Where | How | When |
| Chilean enterprise | Inspection of finished rods $CCP_{B1}$ | Presence of fecal contamination or gastrointestinal contents (visible) | Quality Assurance Monitor | Subsequent to operational step of the finished rod inspection | Visual Inspection: Exterior of legs; Interior and exterior of hindquarter; Interior and exterior of center quarter; Interior and exterior of forequarter; Hands; Interior and exterior of the head. The inspection includes opening of breast folds to check flare fat, ribs and diaphragm. | Every 45 minutes ± 10 minutes, from the beginning of the shift. PCC monitoring starts with the first 5 rods; the following PCC monitoring is performed randomly. To ensure randomness, once the inspection is finished, 2 rods are counted, and the third one is inspected until the 5 channels are completed, and so on every frequency until the end of the shift. The PCC monitoring will end with the last 5 rods. |
| | Rod cooling $CCP_{B2}$ | Temperature and cooling time of rods | Dispatcher (rods) | In the cooling chambers in use. | The temperature of the rods (slaughter is performed during the immediately preceding shift), is monitored at the thermal center level. | At the end of the cooling process, the carcasses to be monitored are randomly defined according to the sample size which varies according to the batch size. The sample size is based on NChx. 44 of 2007. |

**Table 6. Monitoring and follow-up of critical control points according to the HACCP plan in the Mexican packer.**

| HACCP plan | CCPs | Monitoring and tracking | | | | |
|---|---|---|---|---|---|---|
| | | What | Who | Where | How | When |
| Mexican enterprise | Carcass inspection — zero tolerance $CCP_{B1}$ | Presence of fecal contamination or gastrointestinal contents (visible). | Quality Control Supervisor | On hanging line, after the trimming stage | Visual inspection from the top of the leg, the entire hindquarter and forequarter of a carcass, up to the neck, is carried out at 360 degrees of a half carcass. | Frequency of 1 for every 10 channels, the channels to be monitored will be chosen by means of the random method (a draw is made prior to the start of slaughtering, where numbers from one to ten are recorded, and the number drawn is the number of the channel with which monitoring begins after all the channels have that digit as a base). |
| | Storage chamber temperature at 4 °C $CCP_{B2}$ | Monitoring of the ambient temperature of the carcass chambers | Quality Control Supervisor | In the channel camera area | The monitoring start time for chambers 1 and 2 is 9 h. (+/– 10 min), for chambers 3, 4, 5 and 6 the time is 6 h. (+/– 10 min), and for chambers 7, 8 and 9 the time is 4 h. (+/– 10 min), by observing the thermometer located at one end of the chamber door frame on the sacrifice aisle side. | Maintenance shift personnel take and record the temperature every 2 hours (± 10 minutes), starting from the first measurement, additionally during the night and on weekends. |
| | Carcass sanitation $CCP_{B3}$ | Sanitization of half carcasses | Quality Control Supervisor | Right after the vacuum steam intervention | The first carcass to be monitored is determined by selecting a number from 1 to 10; this choice is made at random before starting the process. The monitoring is done by directly observing the sanitization of half carcasses in their entirety, with a frequency of 1 out of every 40 carcasses; the time and consecutive number of the carcass is recorded. | Before starting the process and each time a dose of antimicrobial sanitizing solution is prepared. |

***Variables external to the HACCP plan***

*System certification, annexed integrated management systems*

The directors of the HACCP team of both companies agreed that the choice of the certifying entity was made according to experience and support in the country, where the company operated at international level. The HACCP system at the CE was certified by Certification and Conformity Assessment (Certificación y Evaluación de la Conformidad LSQA S.A.), while for the ME, the certification was granted by the National Sanitation Foundation (NSF). In both cases, certification is renewed every year, as stipulated by the USDA guidelines [20]. Regarding the operation of annexed integrated management systems, the ME applied the Safe Quality Food Program (SQF) management system in conjunction with HACCP. On the other hand, the CE

operated only HACCP as a food safety and quality management system.

*Legal authorizations*

Both companies had all the mandatory authorizations at the national level, issued by the governmental regulatory bodies of each country. They also had permanent official inspections through the assignment of trained inspectors employed by government agencies, who were in charge of monitoring and controlling processes. The CE was authorized by governmental entities such as the Regional Ministerial Secretariat (Secretario Regional Ministerial [SEREMI]) of Health O'Higgins, the Sanitary Action Department and the Agricultural and Livestock Service, whose construction and operation are based on the Food Sanitary Regulations (Supreme Decree 977 of 1996 and Supreme Decree 94 of 2008). It had five current legal sanitary authorizations for the operation of the premises, meat and by-product processing, slaughter lines and holding chambers, animal deboning, product packaging, and the meat slaughter plant. In addition, it had also been approved by the National List of Livestock Product Exporting Establishments (Listado de Establecimientos de Productos Pecuarios [LEEPP]). On the other hand, the ME had two legal sanitary authorizations — one refers to the Federal Inspection Service (Tipo Inspección Federal [TIF]), awarded by SENASICA, and the other was Mexico Supreme Quality (Mexico Calidad Suprema), which is associated with the guarantee of agri-food products with high-quality standards.

*Current authorized in-process and export markets*

The managers defined the types of markets for export products in the two companies. For example, the enabled market was defined as a group of countries where the legal regulations and requirements had been complied with through visits by commissions made up of experts from the importing country and government regulatory delegates from the exporting country. However, regular exports had not yet been made. Markets in the process of being authorized referred to countries where exports were intended, but no legal authorization had yet been granted. Finally, formal export was stated for those markets, where there were actual records of exported products (Table 7). Regarding this last type of markets, the ME registered less than 28.5% of its production to the United States, Canada, Hong Kong and Japan, whilst the CE traded 77.3%. Another relevant aspect to note is the fact that the Chilean packer plant had more significant number of enabled markets, and a greater number of countries with formal exports. A notable aspect is the Russian market, which is considered one of the most discriminating and demanding markets. However, the CE has already exported approximately 30% of its production to this country.

*Personnel age and education level*

The ME had 443 regular employees between 30 to 40 years old. The CE had 272 employees between 20–40 years old; 88.6% were on regular permanent contracts, and 11.4% with time-limited contracts. The level of education varied according to the activities carried out. Concerning the personnel directly involved in the HACCP system and those directly related to technical operations, the monitoring and quality assurance operations were carried out by the quality team in both cases.

The employees' schooling was similar for both packers. The CE packer showed higher employee's schooling than the ME in the 1% employees channeled to quality control and monitoring activities. In addition, it should

**Table 7. Comparison of markets and exports of the Mexican and Chilean packers**

| Mexican packer (ME) | | | Chilean packer (CE) | | |
|---|---|---|---|---|---|
| Markets | | | Markets | | |
| *Enabled* | *In-process* | *Formal export* | *Enabled* | *In-process* | *Formal export* |
| Puerto Rico | Korea | Canada | Russia | Salvador | Russia |
| Canada | Russia | United States | European Union | Colombia | European Union |
| United States | | Hong Kong | Hong Kong | | Hong Kong |
| Saudi Arabia | | Japan | Japan | | Japan |
| Hong Kong | | | South Korea | | South Korea |
| Japan | | | Brazil | | Brazil |
| Vietnam | | | Macao | | Macao |
| Angola | | | Republic of Cabo Verde | | Republic of Cabo Verde |
| Ghana | | | Dominican Republic | | Dominican Republic |
| Gambia | | | Uruguay | | Uruguay |
| Panama | | | Peru | | |
| Qatar | | | Paraguay | | |
| Egypt | | | Ecuador | | |
| United Arab Emirates | | | Bolivia | | |
| | | | Venezuela | | |

be noted that the quality team's level of education and years of experience varied significantly in each case. CE's personnel of the quality team were exclusively college graduated, with a minimum of three years of professional experience in food quality assurance system and HACCP training. These requirements were constantly being renewed. At the ME packer, quality team was made up of some technicians without experience directly related to quality activities. In contrast, all CE personnel were trained directly by professionals in this field, which represents a situation of more significant advantage for the company. The training of Mexican personnel in HACCP was taken externally by the team's management professionals, who in turn gave courses to the rest of the quality team once the packer hired them. This situation could be disadvantageous for the Mexican packer plant, considering the evaluation guidelines for the qualification of demanding markets.

There are reports that the role of employees is a significant factor in the operation of HACCP since knowledge and perception of the system are relevant. The function of the government is highlighted since it is indispensable for training and information campaigns for companies in the food sector [32]. Gehring et al. [33] pointed out that the level of training and supervision in the staff operation has an impact on the operability of HACCP. Therefore, the competencies and knowledge of food company employees have a direct relationship with positive achievements, and this highlights the imperative need for qualified and well-trained managers [34].

*Sanitary performance standards*

As regards the sanitary performance standards, both packers managed them in a similar way for drainage systems, ventilation, lighting, sanitary installations, integrated pest control, liquid and solid waste management, water quality, hygienic operations and facilities, equipment and utensils. Both carried out all corrective actions and contingency measures to comply with the sanitary regulations of each country. Likewise, they were executed in a similar way in terms of managing the personnel involved with job description procedures, staffing, obligations, and continuous training cycles on an annual basis.

Both companies had well-designed and paved access roads. The CE was located within the urban area, while the ME was outside the metropolitan area and required approximately 20 minutes to reach the facilities. Additionally, the CE had a mixed construction that consisted of fixed walls and panels, which can represent an advantage since it is feasible to make changes in the sizes of the areas without incurring exaggerated construction costs and delays. Furthermore, this type of construction facilitates the implementation of corrective actions and the adequate use of space without falling into the error of areas with tiny spaces that increase the risk of contamination or areas with large spaces that hinder the processes of cleaning, sanitization and maintenance of sanitary performance standards, which reduce an increase of hazards.

*Prerequisites*

These programs are indispensable prior to the implementation of HACCP since they are procedures that affect quality and safety of food and guarantee that the company has the basic operational conditions in place [35]. All documentation should have written records, and the HACCP team is responsible for evaluating the prerequisites [36]. In this study, both packers operated a number of prerequisites, which varied from one to the other. The ME had 20 programs in place, and the CE operated 24 programs. Three of them operated in general, and 21 fell into two categories, such as Standard Operating Procedures (SOPs) and SSOPs, with 15 and 6 programs, respectively. In regard to supplier management, both packers had an evaluation and follow-up program inherent in the prerequisites. The design of both programs was analogous since they considered fundamental aspects, such as acceptance and rejection criteria, required documentation and follow-up procedures.

*Suppliers*

As regards this case of study, the supplier management at both packers had evaluation and follow-up programs included in the prerequisites. The design of both programs was alike since they considered basic aspects such as acceptance and rejection criteria, required documentation and follow-up procedures. However, at the ME, other types of control procedures were based on the SQF (version 7.2), which prioritizes the control of suppliers under continuous improvement plans, food defense and environmental protection. It should be clarified that the CE packer did not implement a quality management system that strictly controlled its suppliers. According to the director of the quality assurance system, this was optional because the government regulates all suppliers. For this reason, it was sufficient to request current authorizations from suppliers and apply the basic procedures contained in the supplier program.

Meanwhile, the animal suppliers are regulated in both cases by the respective governmental entities. In Mexico, animals must belong to ranches accredited by the Ministry of Agriculture and Rural Development (Secretaría de Agricultura y Desarrollo Rural [SAGARPA]), while in Chile, they must come from farms under the Officially Certified Animal Stock Program (Programa de Planteles Animales bajo Certificación Oficial [PABCO]). It has been found that 98% of the animals slaughtered in the ME complied with this regulation, while 2% of animals were without any type of accreditation. In this case, the CE had a greater advantage in terms of trust and sanitary quality since 100% of the animals slaughtered had official certification. Prior to the HACCP implementation, the industry and the raw material suppliers involved in the program must identify the system's characteristics, and have the resources for the

initial and maintenance activities of the process [1]. Furthermore, raw material suppliers must have certifications generated by third parties [37].

*Official inspection*

Both packers had a permanent official inspection, which consisted of the assignment of trained inspectors employed by the government, to monitor and control the processes. The two packers had all the mandatory authorizations at the national level issued by the governmental regulatory agencies of each country. These activities were carried out by veterinarians, whom government agencies assigned according to the number of inspectors required by each packer. They applied each company's internal guidelines and analysis. In Mexico, SENASICA assigned four official veterinarians to inspect approximately 400 animals per day. In Chile, SAG ascribed seven similar professionals to carry out the inspection procedures of 2,000 animals per day. In this company, inspectors remained at the assigned inspection points during the entire slaughter day; that is, if there was not at least one official veterinary inspector at each inspection point, slaughter operations did not begin. In contrast, in the ME, antemortem and postmortem inspection was carried out intermittently.

Chilean guidelines stipulate that to be an Official Veterinary Doctor it is necessary to have at least one year of experience in similar positions in the public or private sector, have health compatible with the performance of the position, not be disqualified in any public position, have a professional degree in Veterinary Medicine granted by an institution of higher education recognized by the State and a certificate of courses. The required courses are veterinary epidemiology, veterinary medical inspection of slaughtered animals and meats, dictated by an entity recognized by the SAG, HACCP training, information for auditors, and management of the ISO 9001–2008 standard [38]. In contrast, SENASICA [39] requirements are summarized in personal documents, professional licenses, and proof of training in safety in the processes of production of meat goods, as issued by SAGARPA or academic institutions recognized by this secretariat. However, there are no specific requirements regarding professional experience. Therefore, qualified operators in food businesses are essential as they are necessarily subject to official controls and inspections both national and international in the case of exports [40].

*Geographical conditions*

Although the geographical conditions and location of the packers were heterogeneous, the sanitary status contemplated by the World Organization for Animal Health indicates explicitly that in terms of the diseases of interest for this case study, such as bovine spongiform encephalopathy, foot and mouth disease and classical swine fever, both Mexico and Chile have the recognitions of zones that are free of these diseases [41]. Mustafa [42] stated that geographic factors may constitute adverse factors, along with environmental, social and economic ones. For example, geographical conditions can constitute a threat to public health, like in a situation of lack of feasibility for workers and end users, and can become a drawback for crisis planning as a result of non-compliance with HACCP requirements. Geographical location is also a factor that influences compliance with GMPs protocols and GHPs because companies located in metropolitan areas are more easily accessible for evaluation due to the proximity to high officials and regulatory agencies, which leads to better levels of compliance [43]. In this case study, geographical conditions did not represent a relevant difference as both countries have achieved the same sanitary status.

It was evident in both enterprises that the implementation of comprehensive management systems attached to HACCP was essential for entering international markets. In fact, HACCP alone increases the probability that other countries will more readily accept foreign products with an increase in the export capacity of a company [44]. The HACCP enables exporting companies to design continuous improvement plans that contemplate adjustments not only in the plan but also in other annexed variables. The prioritization based on risk allows adequate optimization of available resources by management and quality control [45].

ME's HACCP plan did not have complete information in the product description as it omitted microbicidal and microstatic processes, which can lead to lower HACCP performance. Sotomayor and Silva [46] found that the lack of complete prerequisite programs is a barrier to HACCP implementation. On the other hand, the CE plan had more advantages in terms of straightforward interpretation of the process flow diagram, product description, CCP identification and system verification. In addition, the CE quality team had higher levels of education and experience than that of the ME. Lopez-Santiago et al. [47] established that technical barriers to HACCP performance include training and experience, among other things, which negatively affect the system.

The categorization of the prerequisites and the follow-up of the recommendations of the Codex Alimentarius and NCh 2861, carried out by the CE, contributed to optimizing the implementation of HACCP, facilitating the auditor's observation and analysis and increasing confidence thanks to the legal support of the system. Moreover, today, the mandatory nature of HACCP is contained and regulated in the health legislation of most countries [48]. Furthermore, the level of trust is strengthened by the fact that the total number of animals slaughtered by the CE came from the farms that were certified by the government control entity, which in turn demanded higher requirements from slaughterhouses and official inspectors, compared with the Mexican government entity. Currently, food production facilities are a subject of a wide range of research in terms of prevailing hygiene and sanitation. Although food safety constitutes compliance with various requirements in the different production links, more significant risks are con-

templated in the production of meat and meat products [26]. It is, therefore, essential to increase this type of case studies in companies that handle meat products in different parts of the world.

**Conclusion**

This article highlights how two packers, one Mexican (ME) and the other Chilean (CE), had the implantation of the HACCP system under national and international requirements. The ME showed an increase in the workload of the quality team without generating relevant competitive advantages for the enablement of international markets. The requirements demanded by the CE for personnel to join the quality team provided an advantage when evaluating qualifications in demanding markets such as the European Union. The quality team personnel of the CE had higher levels of training than that of the ME. In addition, the Chilean governmental control entity was stricter in the requirements for animal slaughterhouses and inspectors in charge of sanitary surveillance, which translated into greater confidence in the country's sanitary quality. Furthermore, all the animals slaughtered in the CE came from farms certified and accredited by the governmental entity, which increased the levels of confidence. On the contrary, this was not observed in the ME. Nowadays, exporting companies in developing countries are immersed in the context of quality and safety control of products. Therefore, it is essential to have quality standards such as the HACCP system certified and operated under the specified requirements. Finally, it is necessary to emphasize that the operability of the HACCP system complies with all the requirements stipulated for access and staying in high-income markets.

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## AUTHOR INFORMATION

**Nury M. Guerrero-Castiblanco,** Master's Degree Student, Animal Science Department, Chapingo Autonomous University. Km. 38.5 Carretera México-Texcoco Chapingo, C.P. 56230, México. Tel.: +52–595–952–16–21, E-mail: guerrerocastiblanco@gmail.com
ORCID: https://orcid.org/0000-0001-7274-9967

**Ema Maldonado-Simán,** PhD Research — Professor, Animal Science Department, Chapingo Autonomous University. Km. 38.5 Carretera México-Texcoco Chapingo, C.P. 56230, México. Tel.: +52–595–952–16–21, E-mail: EMALDONADOS@chapingo.mx
ORCID: https://orcid.org/0000-0002-1692-3198
* corresponding author

**Pedro A. Martínez-Hernández,** PhD Research — Professor, Animal Science Department, Chapingo Autonomous University. Km. 38.5 Carretera México-Texcoco Chapingo, C.P. 56230, México. Tel.: +52–595–952–16–21, E-mail: pmartinezh@chapingo.mx
ORCID: http://orcid.org/0000-0003-2197-3736

All authors bear responsibility for the work and presented data.

All authors participated in the design, analysis, discussion of each topic and writing of the article. Nury Marisol Guerrero Castiblanco and Ema Maldonado-Simán compiled the bibliography and conducted the field phase of the research. Finally, all authors participated in the discussion sessions of the final results and approved the article.

The authors were equally involved in writing the manuscript and bear the equal responsibility for plagiarism.

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