ASPECTS OF COLD CHAIN IN MEXICAN CARRIERS OF MEAT PRODUCTS

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ABSTRACT

Meat products are perishable and their shelf life depends on temperature conditions in the supply chain. Interruptions of the cold chain often occur during transport of meat and meat products, especially in countries with high environmental temperature. Therefore, tracking of the cold chain conditions in commercial carriers is one of the focal points to be addressed. Thus, the objective of this study was to determine aspects of the cold chain in Mexican carriers that give services to the meat industry in the ground transportation. A questionnaire was developed and sent to 52 Mexican meat carries responsible for vehicle fleet for food transportation located in six major cities of the country. Questions were related with vehicles, cooling and freezing technologies, temperature monitoring systems and different aspects related to food quality, safety and logistics. Results indicate that 56% of the carriers used refrigerated chamber with controlled atmosphere (CO_2 enrichment). Resistance temperature sensor was used in 46% of the fleet to measure temperature within vehicles. Continuous control with electronic data loggers to monitor temperature inside the vehicle was applied by 53% of the respondents. Only 17% depended on wireless systems during transport. On weekly basis, chilled meat represented 75% of all of the meat loads transported. The paper provides a general overview of temperature strategies actually followed in transportation of meat within the Mexican market. Whereas this basic-line information, further work is required to develop strategies to be followed in order to improve safety and quality on meat products.

Key words: Cooling technology, meat products, Mexican ground carriers, temperature monitoring.

INTRODUCTION

In the Mexican market, meat products that are ready-to-eat, pre-cooked or at least ready-and-easy to be cooked are on the rising as higher proportions of the population are incorporated to the working force. This demand is paired with long shelf-life span and food safety. Then, food processing has to be done in controlled environments with high hygiene standards; in addition, meat and final processed meat products are to be handled as to avoid any negative microbial activity in them while in transit up to reach the final consumer. Cold chain along all transfers becomes a key factor in the preservation of meat products quality and safety (Beasley, 1998). An effective cold chain is needed through-out production, processing, transportation, and storage of meat and meat products. Failures in the cold chain along any step of the way from the production unit to the final consumers might bring high economic losses; among other sources, such failures in the cold chain may originate from poor equipment and controlling devices and lack of proper supervision. Rodríguez *et al.,* (2011) indicated

that moving enterprises must have a quick and accurate procedure to adjust the parameters of their equipments to keep a constant internal environment regardless the specific conditions of each unit of transportation, route to be covered, geographic area of operation and climate conditions and any other external environmental condition. Potential risk, shelf-life and final food safety and quality are determined by temperature conditions applied in the cold chain (Montanari, 2008).

Morales and de la Torre (2006) pointed out that Mexican carriers that have cooling equipments usually carry perishable foodstuffs: meat, seafood, fish, fruits and vegetables. Other goods that require temperature control as certain drugs and some chemicals are also carried. Common products in the Southeast routes are mango, pineapple, papaya, chili, cucumber, some chemicals, and flowers. Towards the middle region of the country carried products are tomato, avocado, broccoli, zucchini, blackberries, mango and lemon. Temperature range inside the refrigerated chamber of the vehicle is from -29° to 37°C, frozen to fresh; however, for fresh foods common temperature range is from 0° to 8°C, and for frozen products is from -18° to -22°C. Some products require accurate temperature control as slight variations might cause irreversible damages. This fact makes food distributors to be concerned about temperature control in terms of cost component and risk of economic loss (Kue and Chen, 2010). Thus, to provide consumers with high quality meat products, it is relevant to assure the stability of the required cold chain all along the whole process (Bogataj *et al.,* 2005). As temperature data are rarely shared with upstream or downstream chain partners, Raab *et al*., (2008) pointed out the importance of follow-up studies of the cold chain within each segment involved in the food transportation, processing and storage. Thus, the objective of this study is to describe how Mexican transporting companies provide a cold chain in the transportation of meat and meat products.

MATERIAL AND METHODS

Target population was 52 companies registered to transport meat and meat products and with headquarters in one of the six major Mexican cities in terms of shipping or receiving meat and meat products. Five of these cities are in the border with United States, main source of imported meat and meat products. Field data came from a survey applied to those 52 companies. The survey was organized in three segments: *a)* vehicle characteristics, cooling-freezing technologies and measuring procedures; *b)* goods being carried, shipment frequency and length; *c)* control systems and monitoring technology applied (Raab *et al*., 2008). For each question the interviewee was given a set of answers to select from. Surveys were in person, by phone or e-mail. For the statistical analysis proportions for each answer were calculated, these proportions were analysed by Chi Square, using Statistical Analysis System package (SAS, 2009).

RESULTS AND DISCUSSION

Meat and meat products are mainly transported in large loads, that is why 52% of the fleet is composed of trucks with 30 t of load-weight and 16-18 m of box length, these large loads were associated with 71% of the trips lasting over 8 hours and 85% of them covering a distance of 900 km or more. Besides transporting meat in big batches, the transport is very intense as 88% of the companies indicated having daily shipments. Mexico´s size and human population (over a 100 million people) and that over 60% of this population is concentrated towards the middle of the country could explain the load-size and the distance covered on individual trips. In contrast, Raab *et al.,* (2008)

registered that most of German pork and poultry products are transported a distance of 500 km or less. Meat transportation is very intense; however, it is not enough for companies to keep trucks specialized on meat transportation only, 79% of the fleet carry different goods besides meat, most of the time other food products are transported.

Controlled atmosphere was used as cooling technology in 56% of the fleet, while around 40% relies on vehicle cooling system (Figure 1). Rodríguez *et al.,* (2011) indicated that in cold chain management refrigeration system is not as important as the difference between the hypothetical and real behaviour of refrigeration systems; there are many hard-to-control variables that affect the performance of any refrigeration system. It is also mentioned by Morales and de la Torre (2006) the importance of having accurate temperatures for products, as medicine or food, whose specified temperature range should not vary by more than two degrees, because a slight increase causes product dehydration, or a small reduction in freezing, both conditions might cause severe damage.

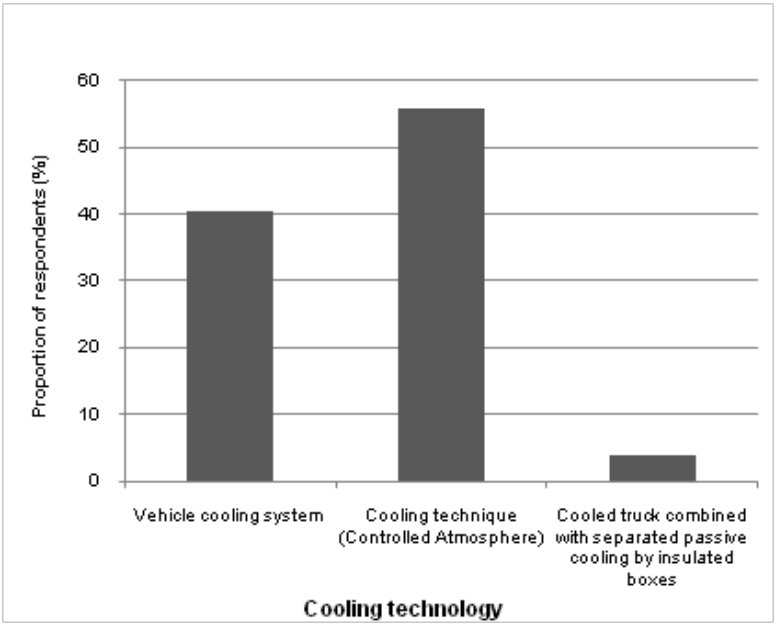

Figure 1. Cooling technologies used by Mexican vehicles carrying meat.

Resistance temperature sensor and thermocouples are used in 46 and 40% of the fleet, respectively as temperature measurement devices (Figure 2). Both systems, as cooling and refrigeration were installed on all transport units. Food quality and safety is guaranteed when cold chain is not broken along any of its chain segments. It could be happened under a number of circumstances, like failure of the temperature control's thermocouples, negligence actions during refrigeration, failures in the cooling system, food permanence for long periods out of refrigeration when loading and unloading of trucks (Rodríguez *et al.,* 2011).

Monitoring of cold chain within vehicles was in 53% of the cases done by electronic data logger, around 18% applied wireless systems, being the second way of monitoring (Table 1). Metzger *et al.,* (2007) indicated that these technologies allow the monitoring of the product's storage and transportation conditions with radio frequency-based technologies, and Kreyenschmidt, (2008) confirmed that this technology can support a continuous monitoring and control of the temperature throughout the entire supply chain.

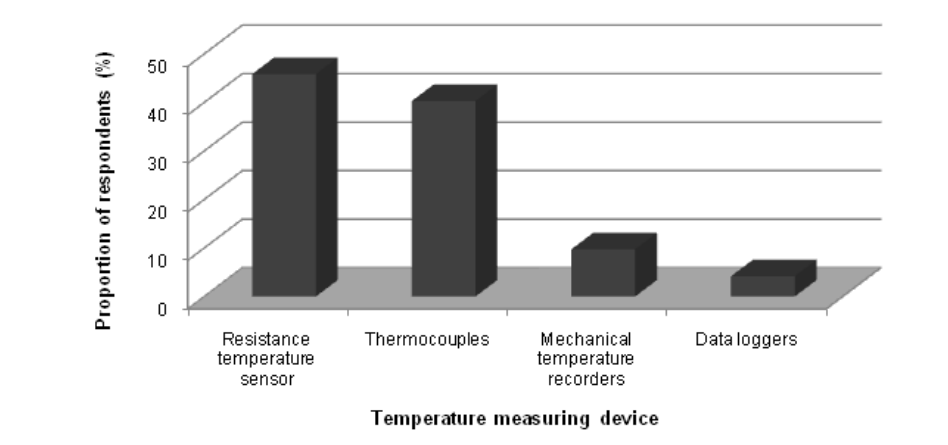

Figure 2. Temperature measurement devices used in Mexican vehicles carrying meat.

Another study mentioned that wireless sensors can be fixed within load, and its readings are closer to accurate in situ properties of perishable food. Conversely, measures made in and within food products could differ from ambient temperature recordings, because of environmental conditions (Ruiz-Garcia *et al.,* 2008). Over one percent of respondents had no technology installed for that purpose (Table 1). It is recorded that efficiency by monitoring the temperature in the cold chain could eliminate or minimise unsteadiness or weaknesses from primary producers to final consumer (Taoukis, 2006; Nychas *et al.,* 2008). Moreover a fruitful implementation and operation of temperature monitoring systems is directly correlated with the method of cold chain management (Bogataj *et al.,* 2005). Although it is advisable, to share real-time data of product characteristics, as well as, gathered temperature that may contribute to the improvement of cold chain management (Raab, *et al*., 2011).

Table 1. Technology applied by Mexican enterprises to monitor cold chain within their vehicles carrying meat.

Technology	**Proportion of respondents (%)**
Continuous control with electronically date logger	53.4
Continuous control with Wireless systems	17.8
Measurement of central temperature (random samples)	11.0
Measurement of surface temperature (random samples)	8.2
Tactile sensors for determination of door opening time	4.1
Time-temperature indicators	4.1
None	1.4

Of the meat weekly transported, 77% was chilled meat, being beef the type of meat with the highest frequency (28%), followed by poultry and pork (23%). A study cited that an approach to cold chain management includes additional information about characteristics of perishable products. There are a variety of aspects, which could affect all cold chain participants (Raab *et al.,* 2011). It is also known that the use of temperature measure aspects is beneficial since temperature acts as the product quality control parameter, and the capacity to measure the impact can justify the change of certain procedure or parameter (Rodríguez *et al.,* 2011). Equally important fact is the knowledge of temperature monitoring systems within all stages of the supply chain, in order to solve the temperature

related problems. Therefore, training programmes, developed by enterprises, play an important role as pre-requisite to be set up in daily business routine (Olsson, 2004). Nevertheless, training courses for a global cold chain management system should include aspects as measurement equipment itself, food characteristics knowledge as well (Raab *et al.,* 2011).

Regarding the type of transportation service, respondents in this study indicated three different ones: 60% was the group of carriers that provide services to meat processing companies. In contrast, one-third of respondents had own transport-service, but they required of hiring a transport service provider company, and only 10% had individual transport fleet to cover all carrying segments. It is relevant to mention the significant economic losses reported by enterprises due to cold breakages. Additional information from Medicines and Healthcare Products Regulatory Agency (MHRA) indicates that between 1999 and 2000 serious infractions were connected during inspections in the control and monitoring of in-transit temperatures of food (Elliott and Halbert, 2005). However, despite the maintenance cost of the cold chain throughout product's entire life cycle, it is essential, as it is was showed, because any breakage causes product deterioration.

Besides, Ovca, and Jevšnik (2009) underlined the importance of maintaining a rigorous control of product storage conditions, in order to have a product in optimum conditions. Then, controlled cold chain management is becoming a key role, where it is included effective and intelligent systems capable to predict the shelf life of a product after processing and estimate of the remaining shelf life at each step in the cold chain (Raab *et al.,* 2008). Consequently, an inter-organizational cold chain management system is becoming more and more important and complex as the meat supply chain turns to a more heterogeneous structure. Thus, cooperation among participants is one of the main challenges to be overcome (Montanari, 2008; Eden *et al.,* 2011).

CONCLUSION

Transport of meat and meat products is done in large loads and over long distances. Carrying companies have own vehicles and cooling systems adequate for maintaining cool chain. Some improvements could be suggested in monitoring cool chain within vehicles**.** Transportation of meat and meat products is not specialized as vehicles that carry meat also carry other goods.

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