



Effectiveness of the cold chain control procedure in the retail sector in Southern Spain



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ABSTRACT

The official procedure adopted in Andalusia (Southern Spain) for implementing the hazard analysis and critical control points (HACCP) flexibility criteria for the control of the cold chain in the retail self-service sector set out in Regulation (CE) 852/2004 is based on a daily determination of the display temperature of the equipment. The main objective of our study was to test whether this approach was effective for the safety of the storage products, considering the influence of the position occupied by the foodstuffs inside the cooling equipment, and also possible seasonal fluctuations. The study was conducted in all self-service refrigerating equipments from every food retail store (11 supermarkets representing different national chain-store groups) located in various municipalities from Southern Spain. Statistically significant ($p \leq 0.05$) breaches in the cold chain were recorded in the case of products located at the top shelf (TST) for all kinds of foodstuffs during the summer period, and also during winter time in the cases of TST of dairy products and refrigerated vegetables. Furthermore, using predictive microbiology as a tool, we calculated the potential reduction caused by those failures on the shelf life recorded in the food labelling of smoked salmon, cooked chicken breast and fresh cheese, which counted up to 40%, 57% and 25%, respectively. These findings show that the official procedure adopted does not ensure compliance with safety specifications of perishable food in the retail self-service sector. A revision of such procedure would be necessary, especially in those regions such as Andalusia where important temperature fluctuations throughout the year are recorded.

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1. Introduction

Refrigerated storage is one of the most widely applied methods for preventing and retarding the growth of pathogenic microorganisms in perishable foods (Jol, Kassianenko, Wszol, & Oggel, 2007). Improper use of this technique, overcoming an appropriate storage temperature, is considered a leading risk factor causing foodborne outbreaks (EFSA/ECDC, 2014; Ray, 2004).

Generally all refrigerated food products are recommended to be preserved at the temperature specified by the processor in the food labelling (temperature control requirement, TCR), established generally between $-1\text{ }^{\circ}\text{C}$ and $2\text{ }^{\circ}\text{C}$, and never exceeding $4\text{ }^{\circ}\text{C}$ (Codex Alimentarius, 1976, 1999). The success of the cold chain depends on several factors such as the ratio time/temperature

(Koutsoumanis, Athanasios, Nichas George-John, & Konstantinos, 2010; Miya, Takahashi, Ishikawa, Fujii, & Kimura, 2010; CFSAN/FSI, 2003), the room temperature (Tirado, Paredes, Velázquez, & Torres, 2005), the kind of refrigerators and the food position within it (Koutsoumanis et al., 2010).

Control of the “cold chain”, defined as *the continuity of successively means to maintain an appropriate storage temperature of foods*, is vital to ensure the quality and safety of refrigerated foods throughout processing, transport, storage and retailing (Codex Alimentarius 1976, 1999; Jol, Kassianenko, Wszol, & Oggel, 2006). It is well known that the early stages of the cold chain (processing and distribution) are, in most cases, successfully controlled (Afchain, Derens, Guilpart, & Cornu, 2005). However, the retail level appears to be one of the weakest points where more temperature abuses have been observed (Derens, Palagos, & Guilpart, 2006; EFSA, 2007). Available data on the compliance

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rate of the retail sector in Europe in controlling the cold chain is still scarce.

In Europe, the need to maintain the cold chain for foodstuffs that cannot be stored safely at ambient temperatures is a compulsory requirement established by Regulation (EC) N° 852/2004 of the European Parliament and of the Council (European Commission (EC), 2004). Article 4 of this Regulation assigns to food business operators the responsibility for compliance with temperature control requirements for foodstuffs, for maintenance of the cold chain, and for compliance with the microbiological criteria for foodstuffs. Moreover, in article 5, the Regulation establishes that food business operators shall put in place, implement and maintain a permanent procedure or procedures based on the hazard analysis and critical control point principles (HACCP), after implementing the food hygiene prerequisites, among which the maintenance of the cold chain is included. Also, Recital 15 of this Regulation sets that the HACCP requirements should provide sufficient flexibility to be applicable in all situations, including small businesses. The European Commission Guidance document published in 2005 to facilitate the implementation of this Regulation, mentioned that in certain cases -particularly in food businesses where no preparation, manufacturing or processing of food is taking place-, the implementation of the prerequisite requirements might be enough to control all hazards (EC, 2005a). With regards to the maintenance of the cold chain, it is essential to monitor temperatures, and check the proper functioning of the refrigeration equipment. However, when the flexibility criterion is applied, reading the display temperature of refrigerators at least once a day is considered a valid method to control the cold chain in retail storage (Carvajal Cámara et al., 2010). That is the procedure mostly applied in Southern Spain, being also adopted by the official control during the inspection of retail food stores.

Commission Regulation (EC) N° 2073/2005 requires compliance with the relevant microbiological criteria throughout the shelf-life, especially regarding *Listeria monocytogenes* in ready-to-eat (RTE) foods (EC, 2005b). This microorganism is among the most important causes of death from foodborne infections in industrialized countries. In Europe the highest levels of non-compliance with this criterion were observed in RTE fishery products, in soft and semi-soft cheese, in other dairy products, and RTE meat products other than fermented sausage (EFSA/ECDC, 2012).

The available risk assessments reports for *L. monocytogenes* elaborated by several agencies (CFRAN/FSI, 2003; FAO/WHO, 2004), point out inappropriate refrigeration as one of the key risk factors that most strongly contribute to the risk of developing listeriosis. With some limitations, the predictive microbiology is an effective tool for estimating *L. monocytogenes* growth in different food groups (EFSA, 2007).

In Spain, from 1995 to 2005, an important shift took place in the distribution of products for home consumption, with an important decrease in the presence of the unorganized retail channel (specialty retailers), towards an increase in organized retailing, especially in the supermarket retail format (Barreiro, 2009a). In 2008 supermarkets have been chosen the favourite option by customers when making food purchases with a share of 46.1% of the total expenditure by households (Barreiro, 2009b).

This study, conducted in Southern Spain, aims to verify if the accepted procedure of reading the display temperature of refrigerators at least once a day to control the cold chain is valid and effective to ensure the temperature requirements for foods that cannot be stored safely at ambient temperatures in self-service retail. Possible breaches in the cold chain were investigated in all refrigerated food categories, considering the influence of the position occupied by the foodstuffs inside the cooling equipment, as well as the possible seasonal fluctuations. Furthermore, using

predictive microbiology as a tool, we assessed whether failures in the proper refrigeration temperature might affect the shelf life of products recorded in the food labelling.

2. Materials and methods

The research was conducted in every retail food store (11 supermarkets representing different national chain-store groups) located in various municipalities from Granada Province (Southern Spain). The study objects were all self-service refrigerating equipments, which summed up: 101 in winter time (12 refrigerators with fresh meat, 8 with meat preparations, 11 with meat products, 30 with dairy products, 10 with fishery products, 5 with ready to eat, 10 with refrigerated vegetables and 15 mixed refrigerators), and 99 in summer time (13 refrigerators with fresh meat, 7 with meat preparations, 10 with meat products, 30 with dairy products, 8 with fishery products, 4 with ready to eat, 10 with refrigerated vegetables and 17 mixed refrigerators).

All managers from the retail stores signed their informed consent to participate in the study, which was approved by the Ethics Committee of the Escuela Andaluza de Salud Pública.

Information about the procedures put in place for the control of the cold chain in each supermarket and the extent to which those procedures were implemented were recorded. Food business operators were also asked about the availability of the temperature control requirements per food/refrigerating equipment, and their understanding about it.

Temperatures were measured between midday and 2 p.m., so it was assured that the stores were opened several hours before and the refrigerators were without night protections during at least two hours. Measures were taken from packed products situated at the most unfavourable places inside the refrigerating equipment, i.e., as close to load limit as possible. A calibrated infrared thermometer model PCE 891 has been used to measure temperatures on the surface of foodstuffs (Calibration n° TS10/7808). All measurements were made both in winter (December 2013–March 2014) and in the summer period (June–September 2014).

In every cooling equipment, the refrigerated food category with a lower TCR was identified. According to the foodstuff with the most restrictive TCR, refrigerators were then classified on the following food categories: fresh meat, meat preparations, meat products, dairy products, fishery products, RTE foods, refrigerated vegetables and mixed (different kinds of foods within the refrigerator).

The following temperatures were also recorded for each of the refrigerating equipment: Temperature of the product on the bottom shelf (BST), Temperature of the product on the half shelf (HST), Temperature of the product on the top shelf (TST), Display temperature on the external monitoring system (DT), and Room temperatures (RT). Room temperature was measured at ceiling immediately close to the fridge.

A non-compliance was estimated when either the DT of a refrigerator or the surface food product temperature at any shelf (BST, HST or TST) were higher than the TCR considered for that refrigerator (food category). The percentage of non-compliance following this approach was calculated for each food category. Differences between temperatures, and the percentage of non-compliance were carried out using a Mann–Whitney's U-test, and a Fisher's exact test, respectively. Differences at $p \leq 0.05$ were considered significant.

In order to check whether the declared shelf life in the food labelling can be guaranteed with the recorded cooling temperatures, a study of predictive microbiology was carried out using the 100 cfu/g limit for *L. monocytogenes* established as criterion for RTE products by Regulation 2073/2005/EC. For doing so, we used the

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