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Cold chain of chilled food in France

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ABSTRACT

This paper presents the results of a cold chain field study in France in 2013 carried out in the framework of a European project named Frisbee. A comparison with the results obtained in a previous field study in France in 2002 was presented. These two studies enabled us to have a real picture of the cold chain because temperature monitoring was carried out in a manner not visible to operators and consumers. These studies concern the cold chain of chilled products from the production plant to storage in a domestic refrigerator.

The Frisbee field study confirms the results observed in previous work that the most sensitive links are transportation after purchase and particularly storage in a household refrigerator. Despite the regulation imposed by the French authorities since 2002 to indicate the cold zone in refrigerators where sensitive products should be placed, the preservation of products at home is still problematic.

Chaîne du froid des denrées réfrigérées en France

Mots clés : Température ; Chaîne d'approvisionnement ; Denrées réfrigérées ; Meuble frigorifique de vente ; Réfrigérateur domestique ; Jambon en tranches

1. Introduction

A better control of the cold chain is of major importance for food safety and is expected by consumers. Today, it is well known that some of the cold chain steps are especially weak, and some studies focus particularly on these points (Carrasco et al., 2007; Dallaire et al., 2006; Derens et al., 2006; James et al., 2008). Nevertheless, the real and complete thermal history of a chilled food product, i.e. from the end of the production line to the consumer remains partly known. Indeed, this thermal history depends on many factors, for example the product logistic circuits and the temperature level encountered at each step of this circuit.

One of the objectives of the Frisbee European project (Food Refrigeration Innovation, Safety Consumers' Benefit, Environmental Impact and Energy Optimisation, 2010–2014) was to develop a European time-temperature database of chilled and frozen products throughout the cold chain. The global objective of the project is to develop the knowledge and innovation of technology used for the cold chain in Europe. To feed the database and to compare the logistics circuits in Europe, field studies were carried out in 4 European countries (France, Greece, Great Britain and Hungary) with a common product,

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the same study protocol, and similar logistics. This paper presents the results of the French study and they are compared with the one obtained in France in 2002 (Ania study).

2. Literature review on field studies of temperature and quality evolution of food products in the cold chain

To provide safe food products of high organoleptic quality, attention must be paid to every aspect of the cold chain from the production plant up to domestic storage. As the product proceeds through different systems during the supply chain, it is difficult to control and maintain the temperature all along the cold chain.

Most surveys monitor food temperatures through cold chain to produce a time temperature history. In addition to temperature monitoring, some of these surveys monitor quality aspects, particularly microbial evolution.

A previous cold chain survey was performed in 2002 in France (Derens et al., 2006) with the French Association of the Food Industries (Ania study). Three types of chilled product were monitored along the cold chain: prepacked meat, ready to eat or to cook product and yogurt. A small temperature recorder was placed inside the packaging of the food product at the end of the production line and sent them throughout the supply chain. At the end, the consumer who discovered the recorder was invited to send it back to the laboratory. 480 recorders were sent and with a return rate of 66%, the time-temperature history of 314 product items was produced. The results indicated that temperature control is critical in the last 3 steps of the cold chain. The average product temperature was 2 °C higher than the recommended value for 7.3% of product in display cabinet, 59.7% in transport after shopping and 40.3% in domestic refrigerator. Another field study was carried out for smoked salmon (200 product items, Morelli and Derens, 2009). This study confirmed the result presented by Derens et al., 2006: i.e. temperature abuse in the last 3 steps. These authors reported that 45% of product (smoked salmon) was consumed within 2 days after shopping and 75% within 7 days whereas the product shelf life was 4 weeks and the recommended preservation temperature was 4 °C. Since the majority of products were consumed within a few days, the safety risk was low in spite of too high temperature in domestic refrigerator.

Landfeld et al. (2011) carried out a survey in the Czech Republic of the time-temperature history of perishable foods after shopping and during home refrigerator storage. The studied product was a model food (21% protein, 23.5% fat, 0.5% carbohydrate) simulating cheese. The time-temperature data was, then, used as input parameter in software which estimated the growth of *Listeria monocytogenes*. The Monte Carlo simulation showed that 27.3% of product would exceed the critical microbial load. The data analysis showed that the greatest influence on the growth of the pathogen was, respectively, time of storage and temperature in domestic refrigerator.

A survey of pasteurized milk in the cold chain was performed in Greece (Koutsoumanis et al., 2010). The time-temperature was recorded by data logger during transportation to retail (83 trucks, recording time 5 days), retail (60 display cabinets, 5–7 days of record in each cabinet) and domestic storages (100 refrigerators, 4 measurement positions: upper, middle, lower, door shelves). The statistical data of milk temperature at different step was, then, used to predict the probability of *L. monocytogenes* growth at consumption.

Table 1 summarises the temperature and duration in different steps obtained from the 4 surveys presented previously. It can be observed that the product temperature during

Table 1 – Statistical result of several surveys of time-temperature monitoring

$N(\mu,\sigma)$ Normal law — μ: mean value; σ: standard deviation. **$Exp(\mu)$ Exponential law** — μ: mean value. **$Log\ N(\mu,\sigma)$** — μ: mean value; σ: standard deviation. **$W(x,k)$ Weibull law** — x = random variable. k = form parametr

Step description	Parameter	Derens et al. (2006)	Morelli and Derens (2009)	Landfeld et al. (2011)	Koutsoumanis et al., 2010
Transport	Temperature (°C)	N (2.9, 1.4)	N (3.6, 2.7)		N (6.7, 1.6)
	Time (days)	*Exp* (0.2)	*Exp* (0.076)		W (1.98; 4.33)
Warehouse	Temperature (°C)	N (2.3, 0.8)	N (3.6, 2.8)		
	Time (days)	*Exp* (3.2)	*Exp* (0.7)		
Platform	Temperature (°C)	N (3.2, 1.3)	N (2.9, 2.9)		
	Time (days)	*Exp* (1.2)	*Exp* (0.49)		
Cold room	Temperature (°C)	N (3.4, 1.7)	N (4.4, 1.9)		
	Time (days)	*Exp*(1.6)	*Exp*(0.95)		
Display cabinet	Temperature (°C)	N (3.2, 1.3)	N (5.6, 2.2)		N (5.0, 2.9)
	Time (days)	*Exp* (4.3)	*Exp* (4.60)		*Log* N (0.83; 0.83)
Transport by consumer	Temperature (°C)	N (7.8, 3.1)	N (13.0, 3.6)	N (11.84, 3.15)	
	Time (days)	*Exp* (0.05)	*Exp* (0.044)	N (0.05,0.06)	
Domestic refrigerator	Temperature (°C)	N (5.9, 2.9)	N (7.0, 3.0)	N (6.5, 2.9)	N (6.3, 2.7) upper position
	Probability of milk position	*Exp* (3.6)	*Exp* (4.8)	N (5.75, 4.44)	N (6.3, 2.7) middle position N (6.7, 3.3) lower position N (8.4, 3.0) door position Discrete (upper/middle/lower/door; 0.25/0.19/0.05/0.51).