Assessment of the impact of consumer behaviors on exposure to Listeria monocytogenes by deterministic and stochastic approaches

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Background

Deterministic models describing heat transfer in cold chain, microbial growth and product quality evolution are widely studied. However, it is difficult to apply them in practice because of several random parameters of the logistic supply chain (ambient temperature varying due to season, product residence time in equipment), and of the product characteristics (initial microbial load, lag time, water activity…). These variabilities can lead to different product evolutions (microbial load, weight losses, firmness and colour change) causing product losses and health risks.

The itinerary (time-temperature profile) and especially the domestic refrigerator, was previously identified as the most importance factor influencing the final contamination of *L.monocytogenes* in cooked ham (*Duret et al*. 2013).

Objectives

To predict the contamination of *L. monocytogenes* in cooked ham at the consumption point taking into account the variability cited previously (logistic supply, chain product characteristics).

To assess the impact of consumer behaviors, season and geographical situation, on the exposure of consumers by *L.monocytogenes*

1 *Materials and Methods*

This study proposes a new approach combining the deterministic and stochastic modeling (Monte Carlo) to take into account the variability of the logistic supply chain for the last three steps, display cabinet, shopping basket and domestic refrigerator.

Figure 1. Last three steps of the cold chain, display cabinet, shopping basket, domestic refrigerator.

The variability of the itinerary and equipments through the cold chain is taken into account. Figure 2 shows the probability of the different itinerary for the last three steps.

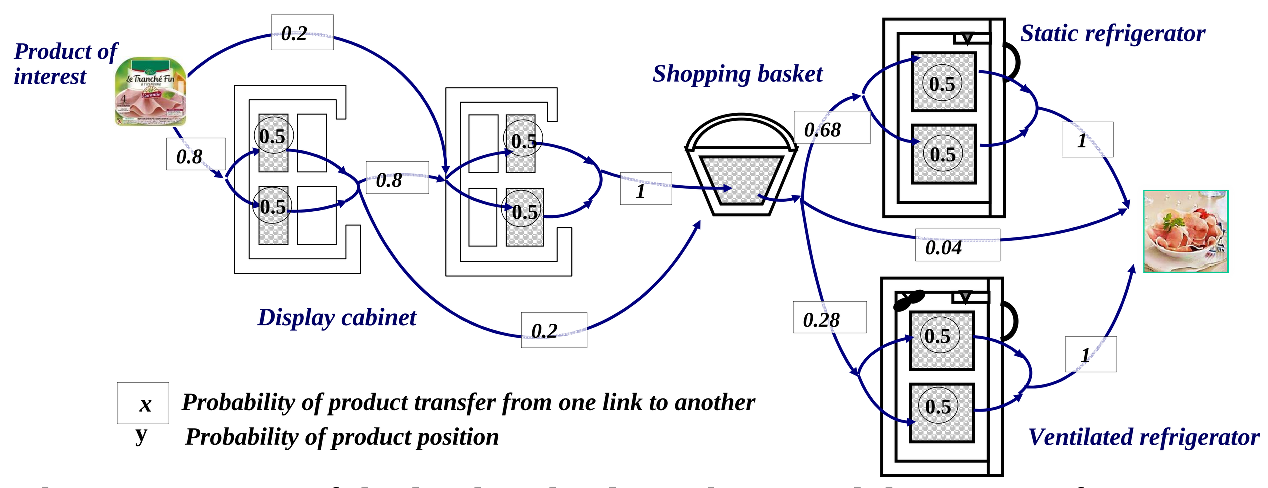


Figure 2. Probability of the different itineraries of the product along the cold.

The temperature of the load in display cabinet and domestic refrigerator are calculated with the deterministic models of Laguerre et al. (2010a) and Laguerre and Flick (2010b). The set temperature of the equipment and the external temperature are random parameters.

The evolution of temperature and microbial growth was performed for 5.10^5. A food safety objective (FSO) was fixed at 100 CFU / g and the **probability of non compliance, P_{nc}, with the FSO** was calculated using an accept and reject algorithm and the following expression:

$$P_{nc} = \frac{n_{rejected}}{\left(n_{accepted} + n_{rejected}\right)}$$

- $n_{rejected}$: number of products above 100 CFU / g.
- $n_{accepted}$: number of products below 100 CFU / g.

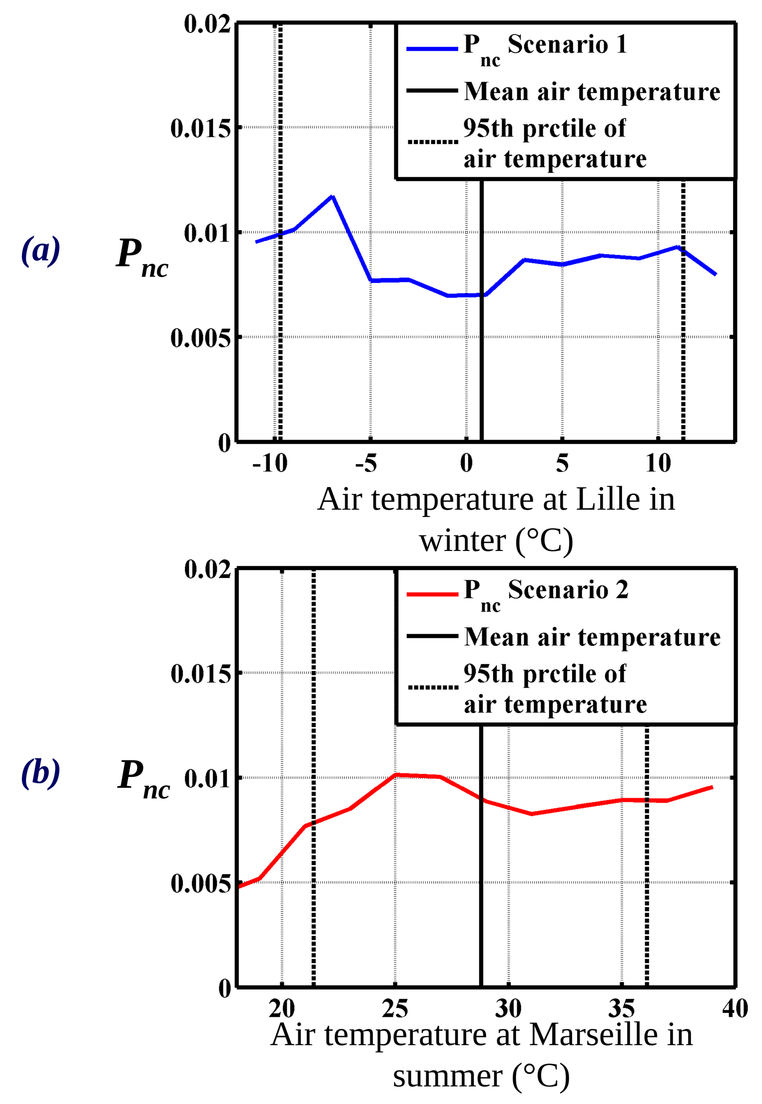
2 *What is the effect of the geographical position and the season ?*

Cold scenario : Lille / winter
mean 0.8 °C ; St. dev. = 5.2 °C

Hot scenario : Marseille / summer
mean 28.8 °C / St. dev. 3.7 °C

Shopping basket

Figure 3. Effect of the air temperature during transport by consumer on the probability of non-compliance P_{nc} of the product (a) cold scenario (b) warm scenario



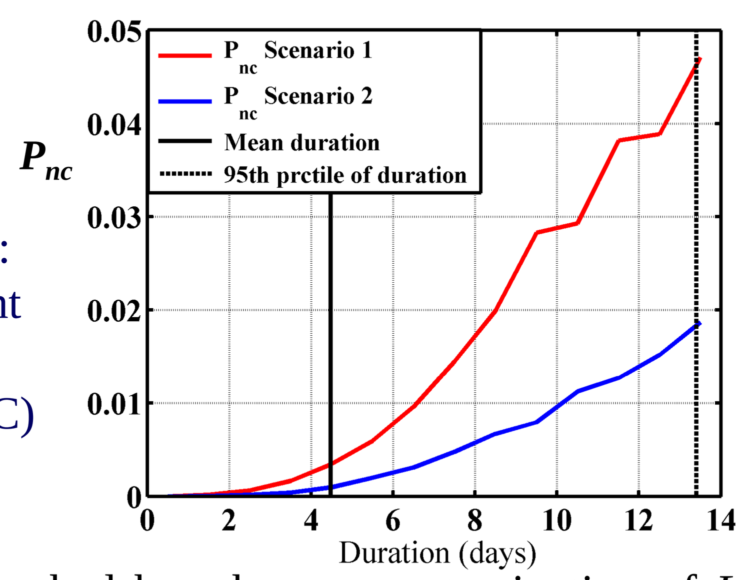
The probabilities of non compliance P_{nc} are equivalent between the two scenarios, the geographical situation and the season has no impact on *L. monocytogenes* exposure. It could be explained by the short duration of this equipment (from 0 to 8 hours).

3 *What would be the effect if every consumers increased the thermostat of the domestic refrigerator of one notch to decrease temperature?*

Actual conditions (Scenario 1):
Mean thermostat setting point 3.2 / 7 (St.dev :1.4)
mean 6°C (St. dev. 2.3 °C)
Laguerre et al. (2002)

New conditions (Scenario 2):
Mean thermostat setting point 4.2 / 7 (St.dev :1.4)
mean 3.8 °C / (St. dev. 2.3 °C)

Figure 3. Effect of the duration in domestic refrigeration on the probability of non compliance P_{nc}. Comparison of two scenarios



Currently, **0.81%** of cooked ham have a contamination of *L. monocytogenes* above 100 CFU/g. If every consumers increased of one notch the thermostat of the domestic refrigerator, **0.3%** of products would not respect the 100 CFU / g and thus, it would reduce the consumer exposure.

4 *What would be the effect if … ?*

Scenarios	P_{nc}	P_{nc}
Every consumers placed properly the product in the domestic refrigerator (e.g. bottom position) / did not pays attention on the product position ?	0.77 %	0.81 %*
Every consumers used an isolated shopping bag / non-isolated shopping bag ?	0.74 %	0.88 %
Every consumers picked products at the rear of display cabinet / at the front ?	0.68 %	0.81 %*
Every consumers did everything right (three previous scenarios) ?	0.54 %	0.81%*
Every consumers did everything right and if they increased of one notch the thermostat of the domestic refrigerator ?	**0.2%**	0.81%*

*Standard case

Conclusions

The exposure of *L. monocytogenes* in cooked ham could be easily decreased by modifying the consumer behaviors. The most efficient and simple instruction consists to increase the thermostat of the domestic refrigerator of one notch.

The numerical tool developed in this study for simulating variability of food itineraries and temperatures can be applied to other products and quality criteria and used by food business operators to assess the impact of the modification of the cold chain logistic or by public organization to give the most pertinent and concrete instructions to consumers

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