1. Introduction
Diced bacon consists in processed pork breasts tumbled with brine and then steamed, diced and packed under modified atmosphere. L. monocytogenes can be present on pork breasts. According to the physico-chemical characteristics of diced bacon growth of the pathogen is possible. Diced bacon is a product usually used in home cooked preparations but occasionally consumed as a raw ingredient.

In this context, a probabilistic model was developed (Billoir et al. in press) to assess the impact of the manufacturing process on the fate of L. monocytogenes and lactic acid bacteria (LAB). Contamination evolution was modeled in the adequate units (breasts, dices, or packaging units) through the successive process steps (arrival, brining, steaming, dicing and packaging). This model did not consider growth during process.

Recently, additional data have been acquired. This concerns (i) L. monocytogenes (detection and enumeration) on pork breasts just after tumbling (Commeau et al. 2009), (ii) fate of inoculated L. monocytogenes in diced bacon (Cornu et al. in press) and (iii) temperatures at the breast’s surfaces and in the surrounding air during steaming.

2. Objectives
The objectives of this work were:

- To refine the process model according to new data collected
- To extend the model for the storing step
- To link the controllable parameters of the diced bacon process according to food safety targets

3. Methods
Refinement of the process model
The modeling approach of L. monocytogenes concentration at arrival was modified. The Bayesian model used to describe contamination at arrival is composed of two parts: the process part and the data one, the latter being composed of detection and enumeration (Commeau et al., 2009).

The previous model presented in Billoir et al. (in press) described concentration on breasts (c*) at arrival with a log-normal distribution. In the new model, c* depends on the logarithm the concentration in a batch (Iconcb).

Iconcb follows a normal distribution of parameter µ0 and σ0. Flat priors were set because very few information about breast contamination at arrival was available. Bayesian estimation of the posterior distributions of the parameters was performed using the software OpenBUGS (3.0.3) (100,000 iterations, 1 chain, thinning of 1,000) and the R package Brugs. The new model of simulation of the contamination is presented in Figure 2.

Growth during heat-up phase of the steaming phase was considered in the new process model. The same primary and secondary growth models as used for post-processing were used to predict growth of LAB and L. monocytogenes.

Extension of the model to post-processing
The model was extended to the post-process storage until consumption. Temperature was assumed to be constant at 8°C throughout it. Growth and competition between L. monocytogenes and LAB were considered. For primary growth model, a model that takes into account Jameson effect was used. The growth competition was considered at the dice level.

For LAB and L. monocytogenes, secondary growth models of Mejilholm and Dalgaard (2007) and Mejilholm et al. (2010) were considered respectively. The following environmental factors were considered for prediction of growth rate: temperature, pH, water activity, lactate, diacetate, CO2.

Between batch variability was taken into account (e.g. for acid content).

Link between control parameters and food safety targets
Several process parameters are directly controllable by the manufacturer: for example temperature and duration of the steaming step. For these parameters we tested different possible values in order to exemplify the link between process control measures and food safety targets. Five scenarios were tested in their ability to comply with different food safety target levels (Table 1). For each, we checked the compliance of diced bacon packages at the end of the storage step with three different food safety targets (1 cfu/100 g, 1 cfu/10 g, 1 cfu/g and 100 cfu/g).

4. Results
The means of posterior distributions for µ0 and σ0 were respectively -2.33 and 0.93.

Primary model associated with secondary growth models for LAB and L. monocytogenes satisfactorily predict the observed data of challenge-testing (Figure 3). These two models were thus incorporated in the storing step of the model.

For all the different sets of process parameters or for a reduced salt level, the probabilities to surpass level higher than 1 cfu of L. monocytogenes/g at the end of the shelf life is small (Figure 4).

Figure 3 illustrates the impact on changing process parameter or diced bacon composition on compliance with a food safety objective.

Table 1. Parameter values for different scenarios of diced bacon processing

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Maximum temperature after heat-up step during steaming</th>
<th>Duration of exposing at maximum temperature</th>
<th>Water activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>45°C</td>
<td>1h30</td>
<td>0.96</td>
</tr>
<tr>
<td>S2</td>
<td>50°C</td>
<td>0h30</td>
<td>0.96</td>
</tr>
<tr>
<td>S3</td>
<td>50°C</td>
<td>1h00</td>
<td>0.96</td>
</tr>
<tr>
<td>S4</td>
<td>50°C</td>
<td>1h00</td>
<td>0.96</td>
</tr>
<tr>
<td>S5</td>
<td>45°C</td>
<td>1h30</td>
<td>0.96</td>
</tr>
</tbody>
</table>

References
Cornu M, Billoir E, Beny S. A probabilistic approach of contamination in foods. Application to the behaviour of Listeria monocytogenes and lactic acid flora in diced bacon. Food Microbiology. Accepted for publication.