Project number: 5994
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BASELINE: Risk targets in milk and dairy products

Key external stakeholders:
Dairy industry, European Food Safety Authority (EFSA)

Practical implications for stakeholders:
The study focused on the risk posed by *Listeria monocytogenes* in raw and pasteurised milk cheese. The study showed that *L. monocytogenes* grew at a faster rate on pasteurised milk cheese compared to raw milk cheese during the storage period following ripening. A quantitative risk assessment model predicting the growth and survival of *Listeria monocytogenes* in raw and pasteurised milk cheese, from farm to fork showed that the mean level of exposure to *L. monocytogenes* in contaminated cheese was higher for raw milk cheese (2.22 $\log_{10}$ cfu g^{-1}) compared to pasteurised milk cheese (<1 $\log_{10}$ cfu g^{-1}). This model can support food processors to optimise conditions to reduce *L. monocytogenes* growth in cheese and to comply with EC2073/2005.

This research was carried out as part of a multi-national EU Framework project, *BASELINE* which focused on research to provide harmonised and validated sampling strategies, supporting European policies in food safety and suitable for food producers to collect comparable data, to improve quantitative risk analysis of selected biological and chemical agents.

Research by Teagasc in this project focused on the growth kinetics of *L. monocytogenes* in semisoft rind washed cheese prepared from raw and pasteurised milk, in the storage period following ripening. Additionally work focused on predicting the risk posed by the *Listeria monocytogenes* contamination arising from the farm environment as well as cross-contamination at processing and retail level, and subsequent human exposure, using a quantitative risk assessment modeling approach.

Main results:

- *L. monocytogenes* grew at a slower rate on the raw milk cheese compared to the pasteurised milk cheese at all the storage temperatures investigated.
- The simulated quantitative risk assessment model showed that the mean level of exposure to *L. monocytogenes* in contaminated cheese was higher for raw milk cheese (2.22 $\log_{10}$ cfu g^{-1}) compared to pasteurised milk cheese (<1 $\log_{10}$ cfu g^{-1}).
- A model sensitivity analysis highlighted the critical factors for exposure to *L. monocytogenes* from both cheeses were the serving size of the cheese, storage days and temperature at distribution stage.
- The model showed that when the Performance Objective (PO) for *L. monocytogenes* in raw milk cheese was set at ≤ 2 log cfu g^{-1} at retail level, nearly 10.34 % of product was predicted to exceed this PO limit, whereas the model predicted 100% of pasteurised milk cheese met the PO target.

Opportunity / Benefit:

The study showed that growth kinetic models can facilitate prediction of *L. monocytogenes* growth during shelf-life and will help to demonstrate compliance with food safety criteria (EC 2073/2005). Further, the quantitative risk assessment conducted based on a farm-to-fork approach also showed possible cross-contamination of raw milk at farm level and retail level. Such model predictions, will allow food processors and policy makers to identify the possible routes of contamination in cheese processing and to reduce the risk posed to human health.

Collaborating Institutions:

18 international collaborators: see page two of the full Technology Update

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External collaborators: **Collaborating researchers in the project included**:
University of Bologna, Italy; Universidad De Cordoba, Spain; University of Zagreb-Faculty of Veterinary Medicine, Croatia; Universidad De Navarra, Spain; Universidad De Lleida, Spain; National Veterinary Institute, Norway; Universite De Bretagne Occidentale, France; Istituto Superiore Di Sanita, Rome, Italy; Centro Nacional De Tecnología Y Seguridad Alimentaria (CNTA), Spain; University of Copenhagen; Denmark; Agence Francaise De Securite Sanitaire Des Aliments, France; Hungarian Food Safety Office; Budapest

1. Project background:

The BASELINE project objective was to develop and deliver harmonised and validated sampling protocols and innovative analytical methods to detect and quantify relevant biological and chemical food risks. The project also focussed on supporting advances in food safety risk assessment to provide the food industry with new insights on pathogens and chemicals in their products and processes. The aim was to generate new knowledge on sampling schemes for risk assessment by using a mathematical approach for different groups of food products including seafood, eggs and egg products, fresh meats, milk and dairy products and plant products. Teagasc main focus in the BASELINE project was on the selection and optimisation of sampling plans for the different risks in milk and dairy products. Researchers focused on developing mathematical models to assess the growth behaviour of *L. monocytogenes* on ripened raw and pasteurised milk stored at retail level. An additional aim was to develop a quantitative risk assessment, which included a prediction of contamination arising from the farm environment as well as cross-contamination at processing and retail level, and subsequent human exposure, using a quantitative risk assessment modeling approach.

2. Questions addressed by the project:

- What is the difference in growth behaviour of *L. monocytogenes* on raw and pasteurised milk cheese?
- What are the interaction effects of water activity and pH on the growth of *L. monocytogenes*?
- What are the risk factors for transmission of *L.monocytogenes* in the cheese chain, farm to fork level?
- What is the probability of human exposure to *L. monocytogenes* following consumption of contaminated raw or pasteurised milk cheese?

3. The experimental studies:

- The growth of *L. monocytogenes* in semi-soft rind washed cheese made from raw and pasteurised milk was investigated at three different storage temperatures (4, 10 and 15^{o}C) over a 28 day period, simulating storage following ripening. Changes in water activity (a_w) and pH in cheeses were also monitored during storage. Response surface models were used to model the interaction of storage temperature and time on a_w, pH and *L. monocytogenes* population. Growth curves were fitted using Baranyi, modified Gompertz and Logistic models at all storage temperatures for both cheeses, and model parameters were statistically analysed.
- The growth kinetics of *L. monocytogenes* in raw and pasteurised milk cheese was modelled from farm to fork, using a Bayesian inference approach combined with a quantitative risk assessment. The modelling approach included a prediction of contamination arising from the farm environment as well as cross-contamination at processing and retail level, and subsequent human exposure.

4. Main results:

- *L. monocytogenes* grew at a slower rate on the raw milk cheese compared to the pasteurised milk cheese at all the storage temperatures investigated. A higher specific growth rate was observed for *L. monocytogenes* in pasteurised milk cheese (0.18 – 0.85 Day^{-1}) compared to raw milk cheese (0.05 – 0.37 Day^{-1}) at all storage temperatures.
- The interaction of pH, a_w and *L. monocytogenes* showed that the population increased with rise in

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pH however a decreasing trend in a_w for both cheese types was observed.

- The simulated quantitative risk assessment model showed that the mean level of exposure to *L. monocytogenes* in contaminated cheese was higher for raw milk cheese (2.22 $\log_{10}$ cfu g^{-1}) compared to pasteurised milk cheese (<1 $\log_{10}$ cfu g^{-1}).
- A model sensitivity analysis highlighted the critical factors for exposure to *L. monocytogenes* from both cheeses, were the serving size of the cheese, storage days and temperature at distribution stage.
- The model showed that when the Performance Objective (PO) for *L. monocytogenes* in raw milk cheese was set at ≤ 2 log cfu g^{-1} at retail level, nearly 10.34 % of product was predicted to exceed this PO limit, whereas the model predicted 100% of pasteurised milk cheese met the PO target
- Simulated exposure level following the consumption of contaminated raw milk cheese showed nearly 97% of product was above the Food Safety Objective (FSO) of ≤ 1 $\log_{10}$ cfu g^{-1}. All pasteurised product meet this FSO. Thus indicating better safety criteria for pasteurised milk cheese compared to raw milk cheese.

5. Opportunity/Benefit:

The study showed that growth kinetic models can facilitate prediction of *L. monocytogenes* growth during shelf-life and will help to demonstrate compliance with food safety criteria (EC 2073/2005). Further, the quantitative risk assessment conducted based on a farm-to-fork approach also showed possible cross-contamination of raw milk at farm level and retail level. Such model predictions, will allow food processors and policy makers to identify the possible routes of contamination along the cheese processing and to reduce the risk posed to human health.

6. Dissemination:

Main publications:

Rivas, L. and Duffy, G. (2010). The European Project BASELINE: Selection and Improving of fit-for-purpose Sampling Procedures for Specific Foods and Risks. International Association of Food Protection (IAFP). European Symposium. 9-11th June 2010. P2-22.

Tiwari, U., Walsh, D., and Duffy, G. (2012). Effect of storage conditions on growth of *Listeria monocytogenes* in pasteurized cheese. International Conference, Global Food Safety: Solutions for Today and Tomorrow. Crowne Plaza Hotel, Blanchardstown, Dublin, October 23 to 25th 2012. Pg. 116. ISBN 84170-591-8

Tiwari, U., Walsh, D., Duffy, G. (2014) Modelling the interaction of storage temperature, pH, and water activity on the growth behaviour of *Listeria monocytogenes* in raw and pasteurised semi-soft rind washed milk cheese during storage following ripening. *Food Control* (*submitted*).

Tiwari, U., Cummins, E., Valero, A., Walsh, D., Dalmasso, D., Jordon, K., Duffy, G. (2014) Quantitative risk assessment of *Listeria monocytogenes* contamination in raw and pasteurised milk cheese from farm to fork. *Risk Analysis* (*submitted*).

7. Compiled by: Geraldine Duffy and Uma Tiwari

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