Quantitative Microbiological Risk Assessment: What about a real-time product specific decision making tool?

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Introduction

Quantitative Microbial Risk Assessment (QMRA) is the fundamental framework for characterizing the nature and likelihood of harm resulting from human exposure to hazards in foods. The food industry, following risk assessors, has shown an increased interest in risk–based food safety tools. The ongoing development of sensors and on-line monitoring devices has enabled "real-time" decision making tools, especially relevant to **vertically integrated brands**.

Material and methods

A baseline QMRA model for *E.coli* O157 in beef patties was developed using exclusively data from the literature. Some of the parameters were then substituted with real-time data (simulated), in order to illustrate the implementation of Real-Time QMRA (RT-QMRA) (Fig. 1).

The baseline model was greatly influenced by Cassin et al. (1998) and Nauta et al. (2001). Modules included were industrial processing, transportation to the facility (restaurant), storage in the facility, cooking and consumption. The three-phase exponential model with lag was used to estimate growth during cold storage, and the model provided by Juneja et al. (1997) was used to estimate reductions in concentration during cooking. For risk characterization, a combination of published dose response models was incorporated. The QMRA model was developed in R programming environment, and the simulation was run for 10000 iterations.

For the **Real-Time variant of the model**, temperature time series for cold storage and cooking were simulated based on literature data (McIntosh et al., 1994; Gougouli & Koutsoumanis, 2017) (Table 1). These time series substituted real-life monitoring that can be achieved with thermocouples or temperature data loggers. Wireless technology can facilitate on-time integration of such data in the model

Significance

- The real-time tracking of the hazard levels enables the **progressive (re)evaluation of risk** for the studied product or lot.
- The final risk estimate retains its stochasticity and becomes **less variable** as single value inputs are integrated.
- **Corrective measures** to achieve the accepted level of risk can be decided interactively along the food-chain continuum.
- It is expected that the proposed approach will support food business operators' interactive decision making.

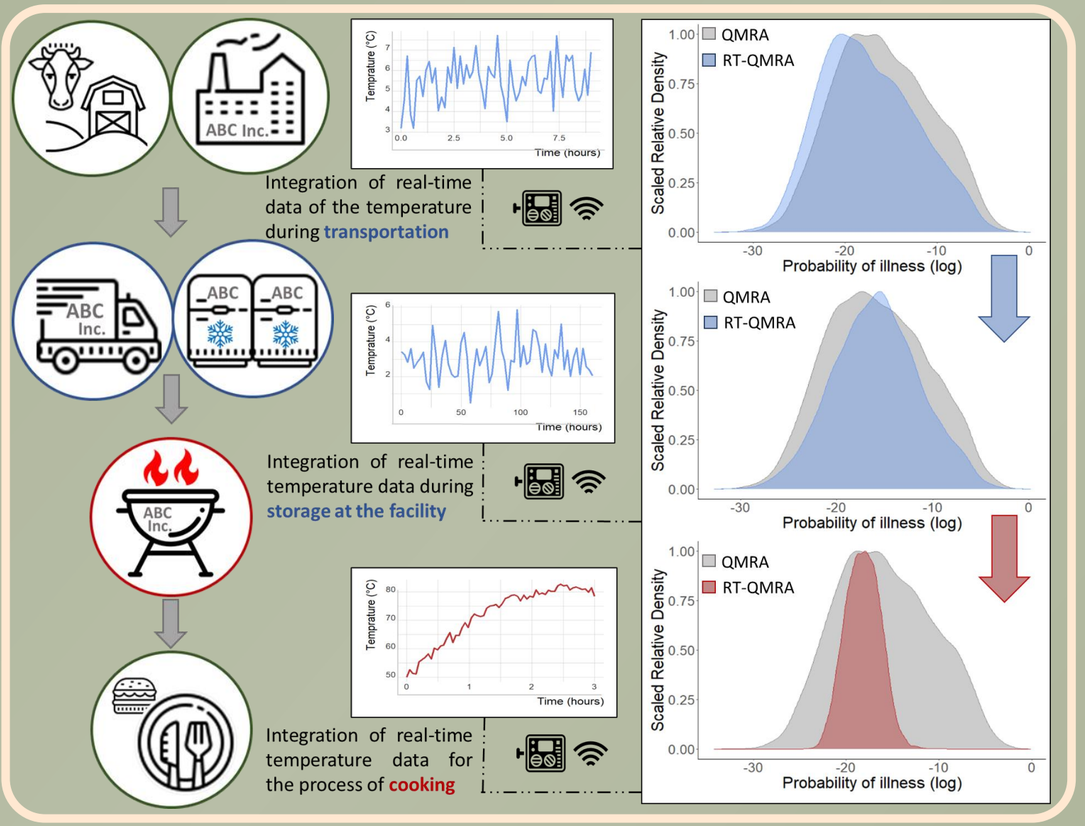

Fig 1. Progressive integration of real-time data in the QMRA model: increasing the precision of the risk estimate

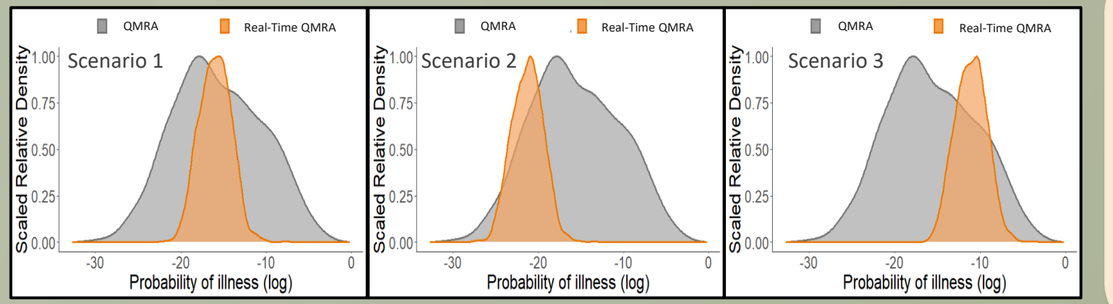

Fig 2. Histograms of estimated risk between the traditional approach and 3 "Real-Time" scenarios

Table 1. Time-series simulated and used in the RT-QMRA

	Mean Temperature (+/- Standard Deviation) °C		
	Transportation	Facility	Cooking (internal)
Scenario 1	5.5 (+/- 0.3)	4.2 (+/-0.8)	71.9 (+/- 9.9)
Scenario 2	3.1 (+/- 0.3)	1.9 (+/- 0.6)	79.6 (+/- 8.7)
Scenario 3	8.1 (+/- 0.8)	6.7 (+/- 0.6)	63.4 (+/- 7.0)

QMRA
Stochastic data from literature

REAL-TIME QMRA
Deterministic data from real-time measurements

Table 2. Measures of variance for the baseline and "Real-Time" approaches (statistic: probability of illness)

	QMRA	Real-Time QMRA
Range	$7.3 * 10^{-5}$	$5.0 * 10^{-3}$
IQR	$8.3 * 10^{-12}$	$1.6 * 10^{-12}$
S.D.	$2.3 * 10^{-6}$	$1.6 * 10^{-4}$
Variance	$5.4 * 10^{-12}$	$2.8 * 10^{-8}$

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Citations

Cassin, M. H., Lammerding, A. M., Todd, E. C. D., Ross, W., & McColl, R. S. (1998). Quantitative risk assessment for *Escherichia coli* O157:H7 in ground beef hamburgers.

Gougouli, M., & Koutsoumanis, K. P. (2017). Risk assessment of fungal spoilage: A case study of *Aspergillus niger* on yogurt.

Juneja, V. K., Snyder, O. P., Williams, A. C., & Marmer, B. S. (1997). Thermal destruction of *Escherichia coli* O157:H7 in hamburger.

Nauta, M. J., Evers, E. G., Takumi, K., & Havelaar, A. H. (2001). Risk assessment of Shiga-toxin producing *Escherichia coli* O157 in steak tartare in the Netherlands.

McIntosh, W.A., Christensen, L.B., Acuff, G.R., 1994. Perceptions of risks of eating undercooked meat and willingness to change cooking practices.