Questions/Answers
Modeling Webinar

November 29, 2017

What is the difference between modeling to well DESCRIBE the data verses to PREDICT?

Answer: There is a distinction between describing the data compared to modelling the phenomenon that leads to the data. For example, the Weibull model (with two parameters, delta and p) may better describe inactivation/survival data with the additional parameter p (compared to a linear model with one parameter), but the p is very much correlated with delta and p is often not very much structurally deviating with environmental conditions, so p is difficult to model. The Weibull model may DESCRIBE better the original data with curvature, but it is not per definition necessarily better in PREDICTING than a linear model with one parameter.

Different techniques target different cellular components. Do we also need then different models?

Answer: Not necessarily. For example, if inactivation is due to heat, pH (organic acid content) and HHP, the target of inactivation (or the mechanism of action leading to inactivation) may be different. Still we can use the same type of model (first order kinetics, Weibull, *etc.*).

What are the best books/references or courses /resources for microbial models?

Answer: There are only a few books dedicated to predictive microbiology, but there are a number of peer-reviewed papers, book chapters and technical reports. Some examples:

- McMeekin, T.A., J. Olley, T. Ross, and D. A. Ratkowsky. 1993. *Predictive Microbiology: Theory and Application*. Research Studies Press, Taunton, UK.

- S. Brul, S. Van Gerwen, and M. Zwietering. 2007. *Modelling Microorganisms in Food*. (eds.) Woodhead Publishing, UK.

- Food and Agriculture Organization of the United Nations and World Health Organization (FAO/WHO). 2008. Exposure Assessment Of Microbiological Hazards In Food; Sec 3.8 - Modelling Microbial Growth And Inactivation; and Sec 3.9, Application of predictive microbiology within exposure assessment. *Microbiological Risk Assessment Series, no 7.* Rome. Accessed January 18, 2018: http://www.who.int/foodsafety/publications/micro/MRA7.pdf.

- McMeekin, T., and T. Ross. 2002. Predictive Microbiology: Providing A Knowledge-Based Framework For Change Management. *Int. J. Food Microbiol*. 78:133-153.

- Montville, T.J., and K. R. Mathews. 2013. Physiology, Growth, And Inhibition Of Microbes In Foods. Chapter 1, pp.3-18. *In*: M.P. Doyle and R. L. Buchanan (eds.). Food Microbiology: Fundamentals and Frontiers, 4th edition. ASM Press, Washington DC, USA. [Note: This Is

Not On Predictive Microbiology *Per Se*, But Provides Foundational Knowledge To Understand Microbial Responses.]

- National Advisory Committee on Microbiological Criteria for Foods (NACMCF). 2010. Parameters for determining inoculated pack/challenge study protocols. *J. Food Prot*. 73:140-202. [Note: This Is Not On Predictive Microbiology *Per Se*, But Provides Foundational Knowledge On Factors To Consider When Evaluate Applicability Of A Model To A Food]

- Ross, T. 2007. Microbial ecology in food safety risk assessment. Chapter 3, pp.51-97. *In:* D.W. Schaffner (ed.). *Microbial Risk Analysis of Foods.* ASM Press, Washington DC, USA.

- Whiting, R. C., and R. L. Buchanan. 1997. Predictive modeling. Chapter 40, pp. 728-739. *In*: M. P. Doyle, L R. Beuchat and T. J. Montville (eds.) *Food Microbiology: Fundamentals and Frontiers*. ASM Press, Washington DC, USA.

Both presenters mentioned that over predictions were not so severe, but they do have financial impact. Comments?

Answer: Predictive models can influence decisions made about product disposition pertaining to food safety. However, we stressed the need to use supplemental sources of data and information in making such decisions. We made these comments with under prediction in mind, but yes, over prediction can perhaps lead to an erroneous presumption that a product is unsafe, leading to costly destruction of the product that could, in fact, be wholesome and safe. In either case of over- or under-prediction, the use of microbiological analysis to validate model outcomes, pertinent peer-reviewed publications, and food microbiology expert assessment can clarify model outcomes and increase confidence in product disposition decisions. There is also some asymmetry in this issue: to destruct some product is costly, but on the other hand illness or even death due to a food safety issue, is more severe. There are a number of ways of assessing model performance (*e.g*. bias and accuracy index; 'acceptable prediction zone' method). It's also useful to consider how well a model has been validated. See next question for more information on model evaluation.

What do you recommend to validate a model, how do we know how good it fits our scenario/situation?

Answer: Before using a tertiary model, we can evaluate the degree to which it has been validated by reviewing the technical documentation provided for the model, such as the source of the experimental data upon which the model was developed, and peer-reviewed paper(s) for the studies that generated the data and developed the model. There are established modeling methodologies that evaluate how well a model performs, *i.e*., how well it fits the original data such as acceptable ranges for bias and accuracy factors. Model validation may involve, for example, collecting a new set of data using different experimental conditions, *e.g*., at a temperature within the range of model prediction but had not been used to generate the original data for model development; collecting data in a food matrix that the model aims to simulate, *e.g*., collecting data in ground beef to evaluate a model developed using data collected in beef broth; collaborative cross-laboratory data collection and model evaluation.

Information about whether a model was developed based on data collected in laboratory broth media versus data collected in a food matrix may be available in the technical documentation provided for a tertiary model. This information, along with information on the extent to which the model has been

validated, would be useful to consider in the evaluation of how well a model may apply to a given situation in day-to-day operations.

Many of the available predictive models have been developed using data collected in broth media, which may not always represent a worst-case or "fail-safe" scenario compared to growth in food. An increasing number of models based on data collected in food matrices or that have been validated through an international collaborative study are becoming available. Appropriate applications of models, developed in either broth media or food matrices, require understanding of the technical underpinning of the models, as well as the food under evaluation (*e.g*., meat and the type of meat), intrinsic characteristics of the food (*e.g*. pH, aw, organic acids, and other preservatives), and the conditions (*e.g*. temperature, gaseous environment).

A model can be further validated by collecting microbiological data. ComBase, for instance, has a feature that enables the user to input actual microbial data along the growth prediction curve. Knowing how good a model fits a given situation comes with education and years of experience. It's best to elicit some help from experts in food microbiology and/or modeling.

USDA PMP stand-alone version is up to 8.0.

Answer: Thank you for correcting the statement made on the webinar that version 7.0 was the latest. PMP 8.0 is available at https://www.ars.usda.gov/northeast-area/wyndmoor-pa/eastern-regional-research-center/residue-chemistry-and-predictive-microbiology-research/docs/pathogen-modeling-program/pathogen-modeling-program-models/. (Accessed: January 18, 2018)

As a producer of fresh beef, what predictive models are designed to account for the processing practices-low temp <4^0 C, use of interventions, GMP, *etc*. for Shiga Toxin-producing *E. coli* control?

Answer: We are not aware of predictive models for interventions for fresh beef, such as aqueous carcass spray treatments. The Refrigeration Index (from Australia) and the Process Hygiene Index (from New Zealand) are models that are accepted by regulatory authorities in those countries. Both models essentially evaluate the potential for growth of *E. coli* as a function of time and temperature. A variety of models, based on experimental data, for inactivation of *E. coli* due to various interventions are available in the published/refereed literature, but do not seem to have achieved regulatory endorsement. It's also worth noting that there has never been a reliable report of *E. coli* being able to grow at temperature less than 6.5°C (and most experts believe that *E. coli* does not grow at temperatures <7°C, *i.e.* growth at less than 4°C is virtually impossible). It's worth noting that no growth does not necessarily mean the risk is under control. For STEC O157 and certain STEC non-O157, both growth as well as the presence of the pathogens may be of concern.

What do you think about using multiple models as validation?

Answer: This can be done to help further understand and research microbial behavior, especially when different models permit entry of different parameters. However, when models are being used for determining the safety of a product, we caution against "shopping around" for any particular model that provides a desirable outcome. When multiple models are used to assess a food product safety, there should be a scientific basis for using one model output over another. The *real* question is whether the model is reliable and relevant to the situation (pathogen, product, storage conditions,

etc.) of concern. The process of determining whether a model is reliable has been commented on above.

Have models been developed for animal feeds?

Answer: We are not aware of growth models for pathogens in animal feeds. But the basic principle of predictive microbiology is that the combination of the conditions of the food and the ecology of the specific pathogen of concern, are among the main determinants of microbiological risk. In the case of animal feed, the same principles should apply, although we expect the main interest will be about whether pathogens can survive at least for dry feed (because the water activity of 'feeds' will preclude pathogen growth) rather than whether there is an increased risk due to growth. The relationship between infection of the animal and transfer of pathogens to humans is complex (for another discussion).

Could you explain when temperature use outside of model would be appropriate?

Answer: Sometimes temperature data is outside of the range of the model for a particular microorganism. The example the speaker was using ComBase Growth Model to predict outgrowth of *Bacillus cereus* and *Clostridium perfringens* during a cooling deviation of a rice/seafood/meat entrée. The temperature data went down to 4°C, but the model range for *B. cereus* is 34 to 5°C, and for *C. perfringens* it is 52 to 15°C. our suggestion in instances such as these was to go ahead and modify your temperatures input (*i.e*. change the 4°C to 15°C) so that you can force a prediction and get a quick look at the outcome for both pathogens of concern in one chart.

In doing so, there would be a possibility of a slight over prediction, but not under prediction. One should avoid altering actual temperature for input into a model when it could result in an under prediction. Keep in mind, this is for convenience and ease of communication of possible growth, so you should state that somehow if you present the output to others. You can always perform separate predictions to more accurately assess potential growth, or you could simply remove the last time point(s) associated with temperatures below the model range. One other thing to point out is that this gets tricky when you have temperature data that cycles in and out of the growth temperature range of the microorganism. In these instances, one should consider whether the model can actually handle that type dynamic temperature effect.

Overall, if you are extrapolating a model beyond the range of the data use to generate it, predictions based on 'conservative' assumptions should be a starting point. Keep in mind that models are not always complete; sometimes models do not cover the complete range of conditions under which growth can occur. You can search for additional published studies and consult other experts as needed. In the case of *C. perfringens*, we do know that it doesn't grow at temperatures less than 10 or 12C; similarly, *B. cereus* doesn't grow at temperatures less than 4 ºC (see Table 5; National Advisory Committee on Microbiological Criteria for Foods (NACMCF). 2010. Parameters for determining inoculated pack/challenge study protocols. *J. Food Prot*. 73:140-202).

Do models take into account ingredients such as celery used to contribute nitrite?

Answer: Models do not specifically take this into account. The main idea of predictive microbiology (and models) is that if you can characterize the physico-chemical environment that the food 'provides' to microbial contaminants, then predictive models will provide a reliable prediction of

growth potential. As such, if celery is an ingredient, it will be important to include the physico-chemical factors that it provides, such as nitrite, and to include that information when making predictions using the model. It will also be necessary to use a model that allows the influence of nitrite to be included in predictions. However, it should be noted that high levels of nitrite are needed to inhibit microbial growth.

Can the growth or source profile affect the modelling dynamics? (*e.g.* organic eggs or produce versus non-organic eggs or produce?)

Answer: See comments in response to question above. Unless organic products differ significantly in their physico-chemical properties from the equivalent 'conventional' products, models will not predict different growth/inactivation potential in those products. Another aspect to consider is whether the initial levels of organisms and their characteristics are different and affect growth differently.

Can you briefly discuss the Food Safety and Inspection Service (FSIS) acceptance of alternative cooling/stabilization processes that can be backed by predictive modelling?

Answer: FSIS-regulated Establishments have many options when choosing the scientific support to demonstrate the cooling and hot-holding process results in acceptable levels of pathogen growth. FSIS provides clarification on this question in its *Compliance Guideline for Stabilization (Cooling and Hot-Holding) of Fully and Partially Heat-Treated RTE and NRTE Meat and Poultry Products Produced by Small and Very Small Establishments and Revised Appendix B*, specifically pages 22-24 for predictive modeling. Establishments should have scientific evidence to support the alternative cooling stabilization process. FSIS will consider (and as a practice tip, the Establishment should be able to answer or justify the decisions made for these points if using a predictive model):

- Is the model validated for the food? If not, has the results of several models been considered to support the Establishment's process?
- Does the model have enough time/temperature data points to get an accurate estimate? and
- Is the modeling based on the "worst case" scenario, have considered the critical parameters of the food (pH, salt level, *etc*.)?

The AskFSIS tool (Accessed January 25, 2018: https://askfsis.custhelp.com/app/home) provides a mechanism for Establishments (and inspectors, consumers) to submit questions and get current information about regulations, Notices, Directives, or other Agency policies.