



# Assessing the Performance of *Clostridium perfringens* Cooling Models for Cooked, Cured Meat and Poultry Products

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## Hazards associated with Stabilization (Cooling)

- Lethality treatment kills vegetative cells, but spores may survive
- During stabilization (cooling), spores may germinate and grow
- Spore-formers of concern in meat and poultry products include:
  - *Clostridium botulinum*
  - *Clostridium perfringens*
  - *Bacillus cereus*
- *C. perfringens* is the target, because the other pathogens grow more slowly



## Data used for evaluating Cooling Models

- Data collected from six publications
- Data used for the models evaluation represented a variety of cooked products, including meat and poultry slurries, ground meat and poultry products with added ingredients (e.g., salt, sugar, sodium tripolyphosphate, sodium erythorbate, sodium ascorbate, and sodium nitrite), and processed products such as ham and deli-style turkey breast
- One hundred eight-five sets of time-temperature cooling profiles, product intrinsic factors, and corresponding growth responses of *C. perfringens* in cooked, cured meat and poultry products were collected to analyze the performance of the five cooling models for growth of this pathogen



# Cooling Models used to Assess Cooling Deviations in Cooked, Cured Products

- *C. perfringens* Cooling Models currently available:
  - ARS Pathogen Modeling Program (PMP) 7.0/8.0
    - Cooked, cured beef
    - Cooked, cured chicken
  - ARS Predictive Microbiology Information Portal (PMIP, a.k.a. PMP Online)
    - Cooked, cured pork
    - Cooked beef
  - ComBase
    - Perfringens Predictor



## Criteria used for Assessing the Performance of Cooling Models

- Criteria based on acceptable prediction zone (APZ) method with the exception that a residual measurement that falls into this range represents an accurate prediction instead of an acceptable prediction:
  - Residual
    - Observed value – predicted value
  - Accurate prediction
    - Residual is - 1 log (fail-safe) to 0.5 log (fail-dangerous)
  - Fail-safe prediction
    - Residual is  $< -1.0$  log
  - Fail-dangerous prediction
    - Residual is  $> 0.5$  log
  - FSIS criterion for acceptable performance and “validation for food safety”
    - $\geq 70\%$  of residual are accurate or fail-safe



# The Performance of the ARS PMP 7.0/8.0 Cooling Model for Cooked, Cured Beef

- Model not externally validated
- FSIS assessment:
  - Accurate predictions (%) – 13.51% (25/185)
  - Fail-safe predictions (%) – 67.57% (125/185)
  - Fail-dangerous predictions (%) – 18.92% (35/185)
  - Model performance
    - 81.08% based on % of correct and fail-safe predictions
    - Meets criterion for acceptable performance



# The Performance of the ARS PMP 7.0/8.0 Cooling Model for Cooked, Cured Chicken

- Model not externally validated
- FSIS assessment:
  - Accurate predictions (%) – 20.54% (38/185)
  - Fail-safe predictions (%) – 56.76% (105/185)
  - Fail-dangerous predictions (%) – 22.70% (42/185)
  - Model performance
    - 77.30% based on % of correct and fail-safe predictions
    - Meets criterion for acceptable performance



# The Performance of the ARS PMIP Cooling Model (PMP Online) for Cooked, Cured Pork

- Model not externally validated
- FSIS assessment:
  - Accurate predictions (%) – 42.16% (78/185)
  - Fail-safe predictions (%) – 31.89% (59/185)
  - Fail-dangerous predictions (%) – 25.95% (48/185)
  - Model performance
    - 74.05% based on % of correct and fail-safe predictions
    - Meets criterion for acceptable performance





# The Performance of the ARS PMIP Cooling Model (PMP Online) for Cooked Beef

- Model not externally validated
- FSIS assessment:
  - Accurate predictions (%) – 19.46% (36/185)
  - Fail-safe predictions (%) – 80.54% (149/185)
  - Fail-dangerous predictions (%) – 0.00% (0/185)
  - Model performance
    - 100.00% based on % of correct and fail-safe predictions
    - Meets criterion for acceptable performance



# The Performance of the UK IFR ComBase *Perfringens* Predictor Model

- Model validated by IFR (published report)
- FSIS assessment:
  - Accurate predictions (%) – 30.81% (57/185)
  - Fail-safe predictions (%) – 66.49% (123/185)
  - Fail-dangerous predictions (%) – 2.70% (5/185)
  - Model performance
    - 97.30% based on % of correct and fail-safe predictions
    - Meets criterion for acceptable performance



## Summary Table of the Performance of Cooling Models for Cooked, Cured Meat and Poultry Products during Single-rate Exponential and Linear Chilling

\* - An accurate prediction is when the Residual is -1 log to +0.5 log; a fail-safe prediction is when the Residual is < -1.0 log; and a Fail-dangerous prediction is when the Residual is > +0.5 log.

\*\* - Acceptable performance for a predictive microbial model is when ≥ 70% of residuals are accurate or fail-safe.

Cooling Model	Number of observations	The % of predictions that were accurate*	The % of predictions that were fail-safe*	The % of predictions that were fail-dangerous*	The % of predictions that were accurate or fail-safe	Meets criteria for acceptable performance (Yes or No)**
PMP 7.0/8.0 Cooked, Cured Beef	185	13.51% (25/185)	67.57% (125/185)	18.92% (35/185)	81.08% (150/185)	Yes
PMP 7.0/8.0 Cooked, Cured Chicken	185	20.55% (38/185)	56.76% (105/185)	22.70% (42/185)	77.30% (143/185)	Yes
PMIP Cooked, Cured Pork	185	42.16% (78/185)	31.89% (59/185)	25.95% (48/185)	74.05% (137/185)	Yes
PMIP Cooked Beef	185	19.46% (36/185)	80.54% (149/185)	0.00% (0/185)	100.0% (185/185)	Yes
Revised ComBase Perfringens Predictor Model	185	30.81% (57/185)	66.49% (123/185)	2.70% (5/185)	97.30% (180/185)	Yes



# Conclusion

- The ComBase Perfringens Predictor and the PMIP cooling model for cooked beef are the most reliable models that food processors and regulatory agencies can use to evaluate the safety of cooked, cured meat and poultry products exposed to cooling deviations
- The cooling models for cured beef, cured chicken, and cured pork are also reliable models that can be used to support the safety of affected product



United States Department of Agriculture

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# THANK YOU!

# DO YOU HAVE ANY QUESTIONS?

