THE UNIVERSITY of TENNESSEE
INSTITUTE of AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
Food Science & Technology

October 21, 2010

Mr. James Yoder
Yoder Brothers Meats
1650 Briar Patch Lake Road
Paris, TN 38242

Dear Mr. Yoder,

As you requested, I estimated the potential hazard involving *Clostridium perfringens* associated with your hickory smoked sausage and your process.

The parameters you gave me included:
Percentage salt - 1.25%
Sodium nitrite - 156 ppm
pH of the product - approximately 6.0
Surface temperature during smoking - approximately 100°F within 1 hour and held for 2 hours; 120°F for 30 min
Internal temperature - approximately 70°F for around 4.5 hours
Cooling time - from 120°F to 40°F in 6 hours maximum
Packaging - Vacuum packaged
Frozen temperature - 10-20°F
Frozen storage - up to 1 year

From this information, I estimated of the potential incidence and growth or survival of *Clostridium perfringens* in your product during smoking, cooling, frozen storage and consumer handling. This was done using the USDA Agricultural Research Service's Pathogen Modeling Program Version 7.0 (PMP) as well as the following resources:

Jay, J.M., M.J. Loessner, and D.A. Golden. 2005. *Modern Food Microbiology*, 7th Ed. Springer, New York.

International Commission on the Microbiological Specifications for Foods. 1996. *Microorganisms in Foods 5. Characteristics of Microbial Pathogens*. Chapman and Hall, London.

Doyle, M.P., L.R. Beuchat, and T.J. Montville (ed.). 2001. *Food Microbiology: Fundamentals and Frontiers, 2nd Edition*. American Society for Microbiology, Washington, DC.

Taormina, P.J., G.W. Bartholomew, and W.J. Dorsa. 2003. Incidence of *Clostridium perfringens* in commercially produced cured raw meat product mixtures and behavior in cooked products during chilling and refrigerated storage. *Journal of Food Protection*, vol. 66(1): 72-81.

A. Incidence (Taormina et al., 2003)

In this study, 152 samples of cured, ground or emulsified raw meat samples were tested for *Clostridium perfringens*:
48.7% were positive for *Clostridium perfringens* vegetative cells and 5.3% positive for *Clostridium perfringens* spores
The average count of vegetative cells of the samples was 117 cells (CFU) per gram (log 2.07 CFU per gram).
The average count of spores was 36 spores per gram (log 1.56 spores per gram).

B. Growth (PMP 7.0)

Internal temperature = 70°F
The predictive model is based on a broth culture (temperature 70°F, pH 6.0, sodium chloride 1.3%, sodium pyrophosphate 0.1%)
The average increase in *Clostridium perfringens* cells after 2.5 hours is nil; **therefore, with an initial number of 117 CFU per gram (from "A"), the potential final number after 2.5 hours would be the same**

External temperature = 100°F, 2 hr
The predictive model is based on a broth culture (lag phase, 2.3 hr, temperature 100°F, pH 6.0, sodium chloride 1.3%, sodium pyrophosphate 0.1%)
The average increase in *Clostridium perfringens* cells after 2 hours was 0.19 log CFU/ml;
Therefore, the potential final number, with an initial number of 117 CFU per gram (from "A") after 2 hours, would be approximately 180 CFU per gram

External temperature = 120°F, 30 min
The predictive model is based on a broth culture (lag phase 0 hr, temperature 120°F)
The average increase in *Clostridium perfringens* cells after 30 min ranges from 0.5 to 3.0 log CFU/ml;
Therefore, the potential final number, with an initial number of 180 CFU per gram after 30 min, would be approximately 570 to 180,000 CFU per gram

The model does not take into account the added sodium nitrite. Sodium nitrite reportedly delays growth of *Clostridium perfringens* in cured meat products (Doyle et al., 2001).

C. Cooling (PMP)

There is potential for slight growth of *Clostridium perfringens* during the maximum 6 hr cooling process. The mean growth for linear cooling from 120 to 40°F in 6 hours is 0.6 log CFU. **Therefore, the potential maximum number would be approximately 715,000 CFU per gram**

D. Storage (ICMSF, 1996)

Clostridium perfringens cells are susceptible to frozen storage with an approximate 94% decrease in viable cells within 14 days at 15°F.

Therefore, after 14 days storage, with a 94% decrease, the population of *Clostridium perfringens* internally in the smoked sausage would be approximately 7,600 CFU per gram.

E. Consumer handling

Clostridium perfringens vegetative cells would be readily inactivated by any cooking process. Taormina et al. demonstrated an average 99% reduction in *Clostridium perfringens* spores in meats subjected to cooking processes of 150 to 174°F.

Therefore, the final populations of *C. perfringens* spores internally in the cooked smoked sausage could be approximately 76 CFU per gram.

F. Hazard

The minimum infective dose of *Clostridium perfringens* to produce symptoms is approximately 1,000,000 to 10,000,000 CFU per gram of product.

The normal outbreak scenario for *Clostridium perfringens* involves non-cured meat and sauce-containing dishes that are cooked and improperly cooled to allow the microorganism to grow to high levels in a food product. The improperly cooled food with high a concentration of cells must then be inadequately reheated to allow the microorganism to survive the cooking process, thereby causing the illness.

F. Conclusion

In conclusion, that appears to be no overwhelming evidence that the product is a major hazard for *Clostridium perfringens*. While numbers of the microorganism on the external surface could reach relatively high levels, the model does not take into account sodium nitrite and is done in microbiological media which makes for a worst case scenario. A further layer of protection against *Clostridium perfringens* is brought about by freezing which will inactivate vegetative cells slowly. Finally, surviving vegetative cells would be killed by the cooking process at the consumer level and spores would be reduced to low numbers. Additionally, if high numbers did exist they likely would be near the external surface where they would be more susceptible to the heat of cooking. In summary, while there are several assumptions

that had to be made to generate these calculations, it does not appear that *Clostridium perfringens* is a significant public health hazard in this product.

Sincerely,

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