Preventing *Salmonella* Contamination of Peanut Products

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Sources of *Salmonella* Contamination

- Primary sources of salmonellae are intestinal tracts of animals (domestic and wild) and humans; shed in feces
  - Feces can contaminate soil and water (irrigation and processing)
  - Salmonellae can survive in some soils for months to years; in water for weeks to months
- Salmonellae can persist in dry environments of food processing facilities for years (e.g., Malt-O-Meal, 10 yrs)

Peanuts

Cultivation, Harvest, Storage

Cultivation

- Seed is planted in April & May
- Approximately 130 days from planting to harvesting
- Cultivated in Virginia, North & South Carolina, Georgia, Florida, Alabama, Mississippi, Texas, Oklahoma, and New Mexico

Harvesting

- Peanuts are harvested from Aug-Nov
- Peanuts are dug, inverted, and left in the field to partially dry for about 3 days before being combined which separates the vine from the inshell peanut

Grading/Storage

- After the peanuts are combined, these “farmer stock” peanuts are taken to a local buying point for grading, drying, and storage until needed for shelling

Storage

- Peanuts are stored in specially-designed farmers stock warehouses until shelled. The raw shelled peanuts are put in one ton tote bags and then go into cold storage warehouses until shipped to manufacturer

Examples of Potential Sources of Pathogen Contamination of Peanuts During Production

- Field fertilized with untreated manure or sewage as a soil amendment
  - *Salmonella* can survive in soil for months or years
- Field irrigated with water contaminated with animal waste
  - Untreated surface water (ponds, rivers) with runoff from livestock operations
- Wildlife grazing on or near fields

Examples of Potential Sources of Pathogen Contamination of Peanuts During Storage

- Leaks in roof on which birds congregate
- Rodent and insect activity, especially if facility is near livestock operations
- Forklift and transport equipment exposed to mud, water or contaminated soil outdoors brought into sheds and warehouses without prior cleaning and disinfection

Essential Conditions for *Salmonella* Growth

- Food/Nutrients
- Water/Moisture
- Temperature

Characteristics of *Salmonella* in Association with Peanut Products

- *Salmonella*
  - Can survive for months to years in low moisture foods such as nonfat dry milk, peanut butter, chocolate
  - Small numbers of this bacterium can produce illness when consumed in high-fat foods such as chocolate (< 1 *Salmonella*/g), peanut butter, cheese

Characteristics of *Salmonella* in Association with Peanuts and Peanut Products

- *Salmonella*
  - Heat resistance increases with decreased moisture content/water activity

    Example

    165°F (instantaneous) kills > 10,000,000 (>7 log) *Salmonella*/g in ground beef, milk, poultry

    194°F for 50 min kills 100,000 (5 log) *Salmonella*/g in peanut butter

    305°F (oven dry heat) for 15 min kills 100,000 (5 log) *Salmonella*/g on peanuts

Characteristics of *Salmonella* in Association with Peanut Products

- *Salmonella*
  - Growth prevented by low moisture content (water activity < 0.95)
  - Growth typically prevented by temperature less than 5°C (41°F) or greater than 46°C (115°F)
    - Optimum temperature for growth is 35 - 37°C (95 - 99°F)

Most Susceptible Populations to *Salmonella*

- Newborns, infants, the elderly and immunocompromised individuals are more susceptible to Salmonella infections than healthy adults
  - Incompletely developed immune system in newborns or infants
  - Weak or delayed immune response in the elderly and debilitated persons
  - Low gastric acid production in infants and seniors

High Fat Content of Food Influences Infectious Dose of *Salmonella*

- High fat content of chocolate (cocoa butter), cheese (milk fat), and nut products (peanut butter) is common factor among foods associated with low infectious dose (< 10 *Salmonella*/g)
- Suggested that entrapment of salmonellae within hydrophobic lipid micelles affords protection against the bactericidal action of gastric acidity
- Rapid emptying of fat-based gastric contents could also provide alternate mechanism

Principles Used in Mitigating Risks of Pathogen Contamination of Peanut

- Preventing contamination throughout the entire cycle, from production to mouth
- Applying control interventions from production to mouth
  - Moisture, temperature, vermin controls
  - Detection of pathogens and indicators of pathogen contamination by testing
  - Chemical antimicrobials
  - Thermal treatments
  - Non-thermal physical treatments (e.g., irradiation, high pressure)
- Responding rapidly to pathogen contamination and taking effective corrective action

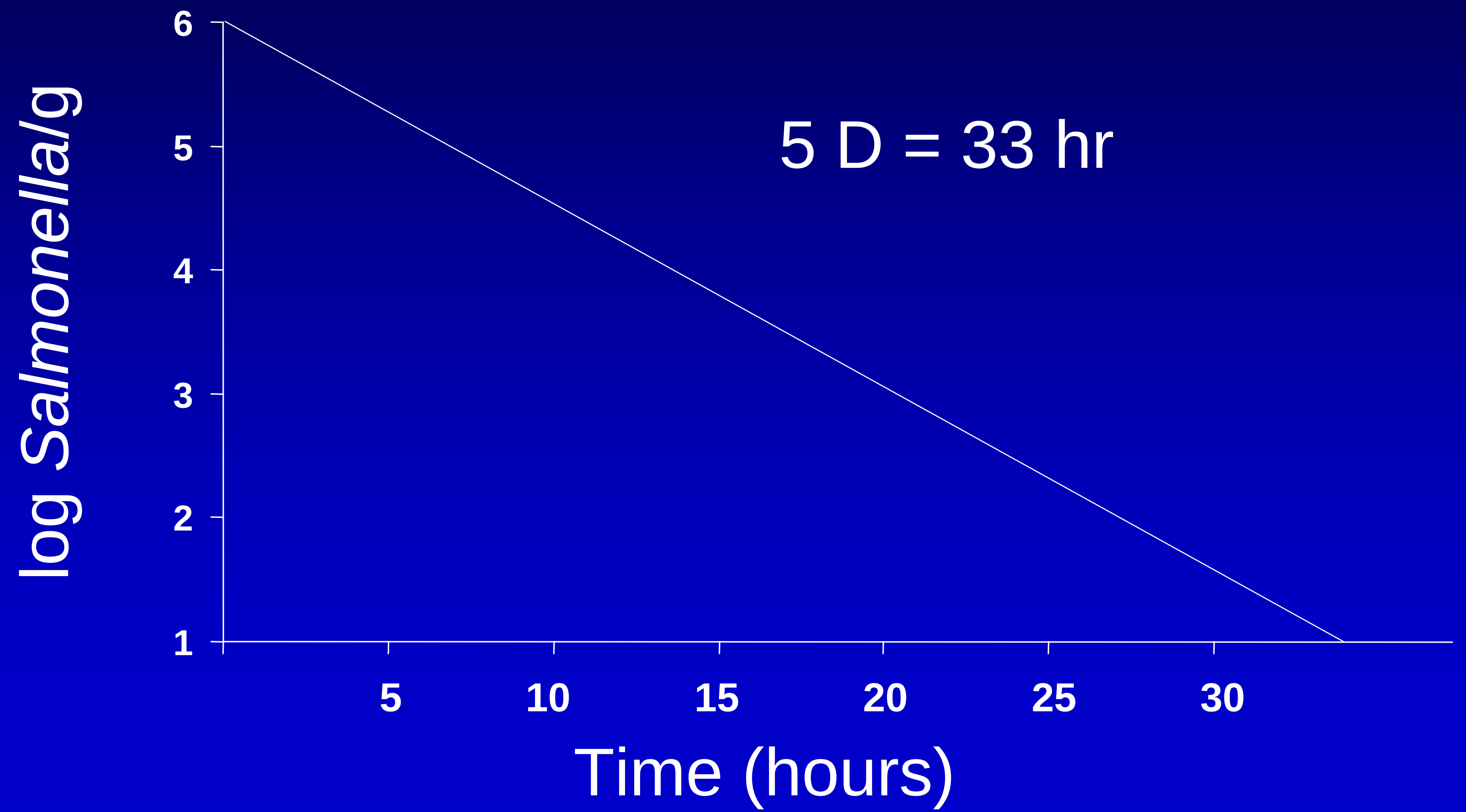
The principles used in mitigating risks of pathogen contamination of foods such as peanut products are applied by the food industry using a systems approach that includes:

- Sanitation Standard Operating Procedures (SSOP)
- Current Good Manufacturing Practices (cGMP)
- **Hazard Analysis Critical Control Point Systems (HACCP)**

HACCP for Peanut and Peanut Product Processors

- Thermal processing is a common treatment (CCP) employed by the nut industry for mitigating pathogenic bacterial hazards

Theoretical Thermal Inactivation Curve for *Salmonella* in Milk Chocolate at 160°F (71°C)



Thermal Inactivation of Pathogens

- Thermal processes are designed to kill a minimum number of a target pathogen (e.g., *Salmonella* or *E. coli* O157:H7)
  - Heat ground beef to internal temperature of 160°F to kill 100,000 (5 log) *E. coli* O157:H7/g
  - Heat canned foods to kill 12 log (12D) of *Clostridium botulinum* spores/g
  - Heat poultry to internal temperature of 165°F to kill 5 log *Salmonella*/g
  - Heat almonds (peanuts) to kill at least 10,000 (4 log) *Salmonella*/g

What Should Be the Targeted Log Reduction for *Salmonella* on Nuts/Nut Products to Ensure Safety?

Thermal Inactivation of *Salmonella* in Peanut Butter[a]

Internal Temperature (°C / °F)	Mean maximum time (min)		
	3-log reduction	5-log reduction	7-log reduction
71 / 160	107	402	965
77 / 170	62	197	423
83 / 181	33	110	227
90 / 194	21	49	120

[a] Commercial, creamy-style peanut butter; a_w = 0.45, pH = 5.1

Ma et al., J. Food Protect. July 2009

Considering the high temperature and extended heating time needed to kill 5 log of *Salmonella* in peanut butter (49 min at 194°F or 3.3 h at 170°F), this is not likely a suitable treatment to render a product of acceptable quality

Therefore, the key **critical control point** to ensure safety from *Salmonella* contamination from raw nuts in peanut butter/product manufacture is the whole nut roaster

If the roaster conditions are designed to kill 100,000 (5 log) *Salmonella*/g, then the incoming load of *Salmonella* on peanuts must be less than 5 log or greater than 1 *Salmonella* will be present per gram of peanuts

- Areas of localized *Salmonella* growth, as occurs with *A. flavus* for aflatoxin production, can be a confounding factor

Thermal Inactivation of *Salmonella* on Unblanched Virginia Peanuts by Dry Roasting

Oven Temp (°C / °F)	Time (min)	log reduction
129 / 264	45	4.3
146 / 295	15	4.9
163 / 325	10	5.8

S. Goodfellow (Deibel Lab)

Conclusions

- Peanuts are now considered high-risk foods with regard to *Salmonella* contamination
- The low-moisture, high-fat content of peanuts contributes to the:
  - High temperature, extended time required to kill *Salmonella*
  - Lower infectious dose of *Salmonella*
  - Long-term persistence of *Salmonella* in peanut products

Conclusions

- Mitigation of *Salmonella* contamination of peanuts should be addressed from production to consumption
- Peanuts should be produced and stored under conditions to prevent *Salmonella* growth
- The roaster is critical to ensuring the safety of peanuts
  - Temperature-time conditions for nut roasting must be validated to ensure efficacy in killing the targeted number of *Salmonella*
  - Roaster conditions, including peanut bed depth and uniform loading, and accurate monitoring of temperatures and time, must be properly controlled