Salmonella in Low-Moisture Foods and Ingredients

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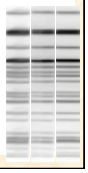
Outline

- *Salmonella*
  - Characteristics
- Salmonellosis
  - Example outbreaks
- Myths and misconceptions
- Summary

Salmonella – factoids

- *Salmonella enterica*
  - Primary source: intestinal track of humans/animals
  - Approximately 2,500 serovars
    - Enteritidis, Montevideo, Typhimurium are serovars
  - Serovars can by subtyped by many different methods
    - Phage typing
      - *Salmonella* Enteritidis PT 8, 13a, 4, are common
      - *Salmonella* Enteritidis PT 30, 9c are rare
    - Fingerprinting (PFGE)
      - Used to further distinguish serovars of *Salmonella* and other pathogens



Salmonelloisis factoids

- Associated with many foods
  - Animal origin (meat, poultry, eggs, dairy)
  - Raw fruits and vegetables
  - Low-moisture foods
- Symptoms range:
  - None to severe (septicemia infection of blood)
  - Most common:
    diarrhea, fever, vomiting, dehydration, cramps
- Long-term impact: reactive arthritis
- Infective dose:
  - In some cases estimated less than 15 to 20 cells
  - Low in dried foods?
    - Depends on age and health
    - Probably serovar, physiological state, food matrix

Salmonellosis and low-moisture foods 1990-

- **Outbreaks with spices**
  - Spices: Pepper, paprika (1995, 2009, 2009-10)
  - "Veggie Bootie" seasoning (2007)
- **Outbreaks with nuts, seeds, legumes:**
  - Almond (2000-01, 2003-04, 2006)
  - Coconut (dried) (1999)
  - Peanut (1994-95, 2001, 2005)
    - peanut butter (1996, 2006, 2009)
  - Sesame seed
    - Halva (2001), Tahini (2002, 2003)
- **Outbreaks with other dry foods and ingredients:**
  - Chocolate (2001-02, 2006)
  - Skim milk powder, dried eggs (1993, 2005, 2008)
  - Cereal (1998, 2008)
  - Dry pet food/pet treats (2004-05, 2006-07, 2008)

Salmonellosis and low-moisture foods 1990-

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Long shelf life

Consumed without further kill step

Often ingredients in foods

Apparently low infectious dose

    - Halva (2001), Tahini (2002, 2003)
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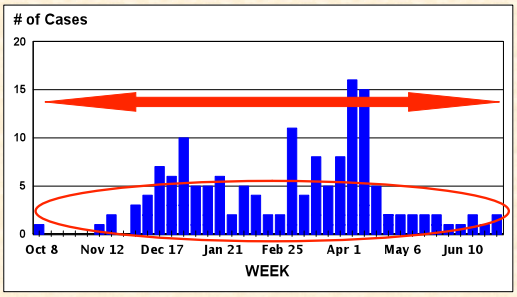
Why Apparent Increase?

- Increased National focus on food safety
- Epidemiology
  - Increased investigation, cooperation, technology
- Microbiology
  - Improved methodologies
    - Routine subtyping (serotyping/fingerprinting)
      - Digital sharing of fingerprints across the US
      - International collaboration
    - To date, most low-moisture food/ingredient outbreaks have been associated with rare serovars or unique fingerprints
      - Facilitated investigation of widespread, sporadic illnesses

Outbreak of salmonellosis (*S.* Enteritidis PT 30) in raw almonds



CDC, 2005

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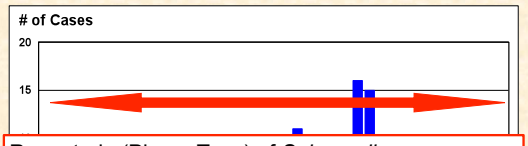


Rare strain (Phage Type) of *Salmonella*

Protracted outbreak (8 months)

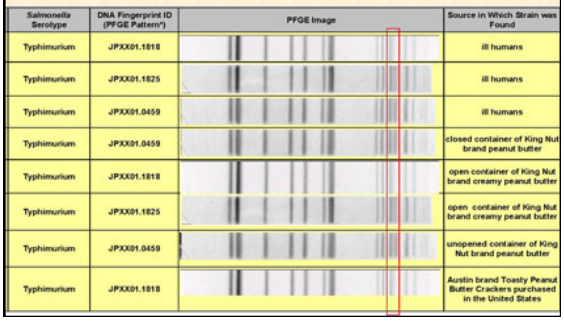
International: Ontario, Canada routinely phage typing *S.* Enteritidis isolates

Isaacs et al. 2005. JFP 68:191-198

Peanut Butter 2008-2009

CDC, 2009

Salmonella Typhimurium, rare fingerprint

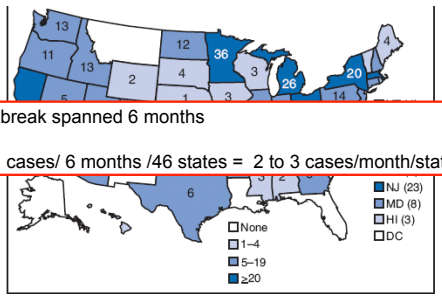


Salmonella Serotype	DNA Fingerprint ID (PFGE Pattern*)	PFGE Image	Source in Which Strain was Found
Typhimurium	JPXX01.1818		ill humans
Typhimurium	JPXX01.1825		ill humans
Typhimurium	JPXX01.0459		ill humans
Typhimurium	JPXX01.0459		closed container of King Nut brand peanut butter
Typhimurium	JPXX01.1818		open container of King Nut brand creamy peanut butter
Typhimurium	JPXX01.1825		open container of King Nut brand creamy peanut butter
Typhimurium	JPXX01.0459		unopened container of King Nut brand peanut butter
Typhimurium	JPXX01.1818		Austin brand Toasty Peanut Butter Crackers purchased in the United States

666* (691) cases in 45 (46) states and Canada (1)

>119 hospitalizations, 9 deaths

CDC, 2009



Outbreak spanned 6 months

691 cases/ 6 months /46 states = 2 to 3 cases/month/state

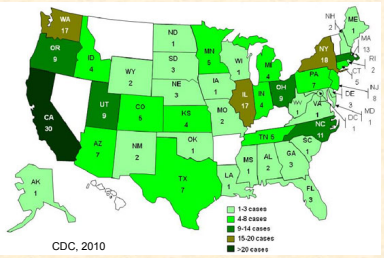
*Cases reported as of February 24, 2009. Cases reported in the previous 3 weeks might not yet be reported.

Peanut Butter 2008-2009

- Recall of 3182 products over 2 years
  - 2007 to 2008
- Product used as an ingredient
  - Peanut paste
  - Greatly complicates epidemiology
- Items as diverse as pet food, ice cream and energy bars

Salami 2009-2010 (9 months, 44+ states)
(Black and Red Pepper - ingredient)

Salmonella Montevideo + *Salmonella* Seftenberg (?)
252 cases + 9? (4/1/10, CDC update)



CDC, 2010

Numerous Recalls

USDA/FSIS – meats long shelf life

FDA – spices

Salmonella Montevideo

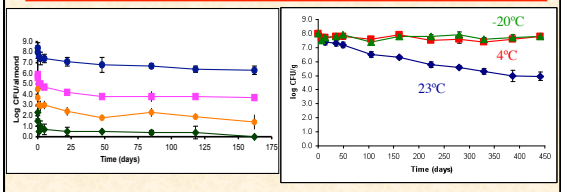
- Common serovar (top 10), common fingerprint
  - CDC used new statistical method to determine if cases from PulseNet (reporting system) were above historical normal
  - Shopper card information used to narrow foods/ brands
    - Ill persons gave permission, case control study
  - More identified outbreaks in future?

Salmonella – myths and misconceptions

- *Salmonella* doesn't survive at cold temperatures
- *Salmonella* doesn't survive in dry foods
- *Salmonella* has a high infectious dose
- *Salmonella* is easily killed by heat (in dry foods)
- Traditional cleaning and sanitation can be applied to dry food processes.

M/M
Salmonella doesn't *survive* dry conditions or in the cold

How well does *Salmonella* survive on almonds?



Calculated reduction is:
23°C (73°F) 0.25 log CFU/month
4ºC (39°F) 0 log CFU/month
-20ºC (-4°F) 0 log CFU/month

1 log is a 10-fold or 90%

Uesugi, Danyluk and Harris, 2006 JFP 69:1851-1857

How well does *Salmonella* survive on almonds?

Long-term survival (months) noted in:
- Chocolate
- Halva
- Pecans (Beuchat, unpublished)
- Pistachios (Harris, unpublished)
- Black pepper
- Walnut kernels (Harris, unpublished)

1 log is a 10-fold or 90%

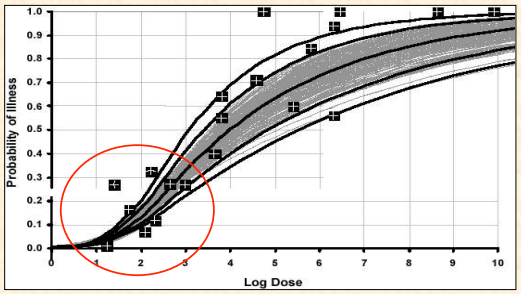
Uesugi, Danyluk and Harris, 2006 JFP 69:1851-1857

M/M
Salmonella has a high infectious dose

1950s estimates near 100,000/serving

Assumption - growth:
nutrients, moisture, temperature and time critical factors for outbreaks

Dose Response Model



β-Poisson Dose-Response model for *Salmonella* spp. FAO, 2002.

Examples of salmonellosis outbreaks with known low infectious doses

Food	*Salmonella*	Infectious Dose (cells per serving)
Cheddar cheese (1976)	Heidelberg	100
Cheddar cheese (1984)	Typhimurium	1 to 10
Chocolate (1973-74)	Eastbourne	100
Chocolate (1982)	Napoli	10 to 100
Chocolate (1987)	Typhimurium	≤10
Paprika coated potato chips (1993)	Saint-paul, Javiana, Rubislaw	≤45
Ice cream (1994)	Enteritidis	≤28
Almonds (2001)	Enteritidis PT30	<10 to 200+

Salmonella in low-moisture foods: Survey of Almond Kernels (100 g)

Year	Number Positive	% Positive	MPN/100 g	Number MPN >1.2 /100 g
2001	12 of 2003	0.60	Not done	Not done
2002	24 of 2012	1.2	<1.2 - 2.9	1 of 24
2003	15 of 1764	0.80	<1.2 - 1.4	3 of 15
2004	12 of 1643	0.73	<1.2 - 1.4	1 of 12
2005	18 of 1852	0.97	<1.2 - 1.4	1 of 18
2006	30 of 1899	1.6	<1.2 – 15.5	10 of 30
2007	15 of 1799	0.83	Not done	Not done

Average 0.99% positive samples per year

Levels less than 3 to 15.5 MPN/100 g

Uesugi, Danyluk and Harris, 2007 JFP 70:820-827

Surveys - Spices

- Few have been done
  - Typical: small sample size (number tested, weight tested), multiple products and sources, retail sampling
- Retail Surveys – UK
  - *Salmonella* in 25-g samples
  - *Salmonella* in 23 of 3735 "seeds" (0.6%): 13 sesame seed
    - Willis et al., 2010. Food Microbiol. 26:847-852
  - *Salmonella* in 31 of 2833 retail samples (1.1%) and 2 of 132 wholesale samples (1.5%)
    - 17 serotypes from 16 herbs/spices
    - Sagoo et al., 2010. Food Microbiol. 26:39-43.

Julseth R.M., R. H. Deibel. 1974. Microbial profile of selected spices and herbs at import. J. Food Prot. 37:414-419.

113 samples – 11 different spices and herbs Imported into US

The results of this investigation gave no indication of a potential health problem associated with spices and herbs.

It would appear that spices, like other food ingredients, may in rare instances become contaminated with microorganisms of public health significance.

However, multiplication in these dried products is precluded, and longevity of vegetative cells in the dry state appears to be limited.

Recalls – Spices

- 1970-2003
  - Vij et al., 2006, J. Food Prot. 69:233-237
    - 21 recalls
    - 20 for *Salmonella*
    - 1 for *Listeria monocytogenes*
- 2004-present
  - ?

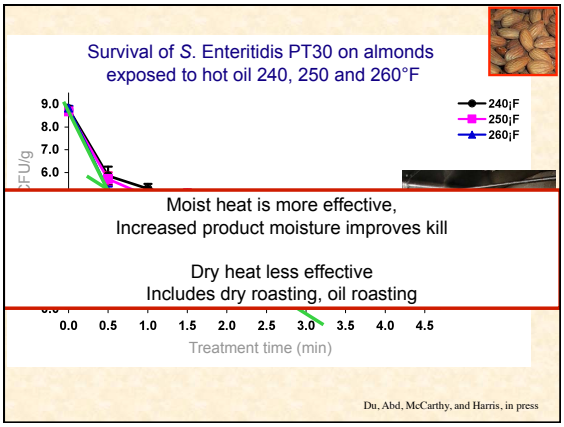
Recalls – Nut Products

- almonds (01,04), hazelnuts (09), macadamia (09), peanut butter (07, 09), pecans (09), pistachios (09), pine nuts (10)
  - *Salmonella*
- walnuts (09)
  - *Listeria monocytogenes*

Recalls? What's New?

- Buyer testing programs
  - have increased sampling and sample size
- FDA directive
  - Field assignment to inspect nut facilities and to do environmental swabs of facilities
  - Reportable Food Registry (2009)
- Success of nut industry?
  - Record crops, increased consumption, switch to out of hand, raw

M/M *Salmonella* is easily killed by heat



Time to 4- or 5-log reduction of *Salmonella* Enteritidis PT 30 on almonds exposed to hot oil, according to the Weibull model 99% Confidence Interval

Temperature (°C/°F)	Time required for reduction (seconds)	
	4-log 10,000 fold	5-log 100,000 fold pasteurized
116/240	114	234 2 X
121/250	72	132 2 X
127/260	39	72 2 X

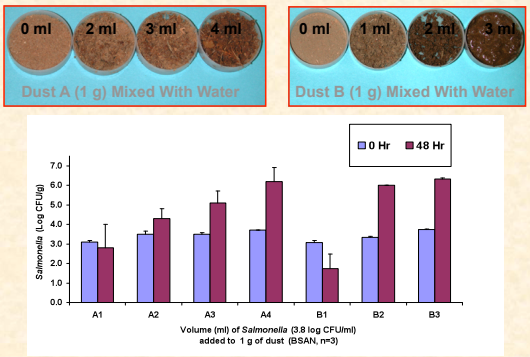
Du, Abd, McCarthy, and Harris J. Food Prot., in press

Antimicrobial Treatments: Spices

- Irradiation
- Gas
  - Ethylene Oxide, Propylene Oxide
- Steam
  - Multiple systems
- Little *published* data available

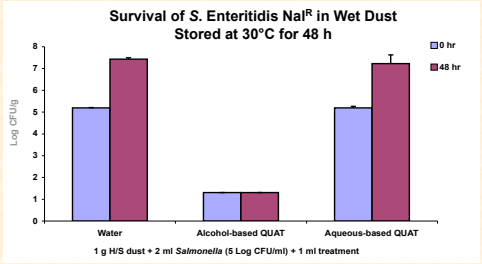
M/M
Traditional cleaning and sanitation can be applied to dry food processing facilities.

Salmonella Grows in Wet Almond Dust



Du et al, .2010. J. Food Sci. 75:M7-M13

Salmonella is Unaffected by Addition of 200 ppm Aqueous QUAT to H/S Dust



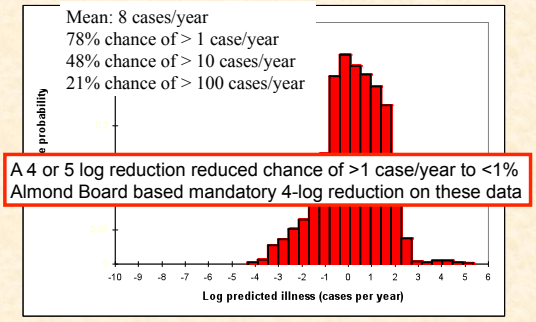
Du et al. 2010. . J. Food Sci. 75:M7-M13

Cleaning/Sanitizing

- Water should be avoided unless:
  - Removal of dusts can be assured
  - Complete drying of equipment/facilities can be ensured

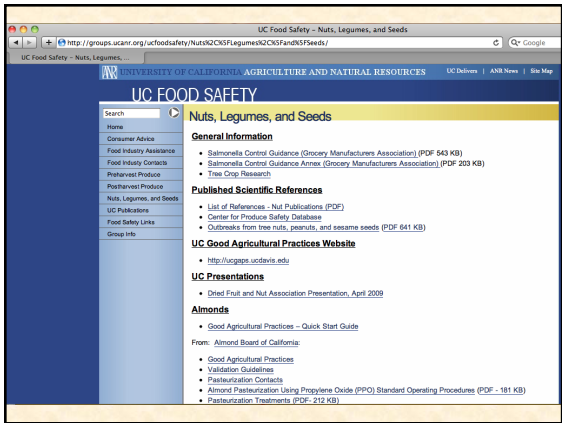
Making Sense of All the Data

Risk Assessment of salmonellosis from Consumption of Raw Almonds (Annual Illness) (@Risk Modeling Program)



A 4 or 5 log reduction reduced chance of >1 case/year to <1%
Almond Board based mandatory 4-log reduction on these data

Danyluk, Harris, and Schaffner, JFP 2006 69:1594-1599



Summary

- Low-moisture foods including are increasingly recognized for association with *Salmonella* and salmonellosis
- Challenges: low prevalence, long-term survival, enhanced resistance, low infectious dose?
- Herbs and Spices
  - Very large category
  - Risks may differ but generally categorized as one
- Control
  - Good Agricultural Practices, Validated Processes, post-process Good Manufacturing Practices