Persistance and Survival of Pathogens in Low Water Activity Environments

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Low Moisture Foods

- Over recent years numerous outbreaks of food poisoning associated with low Aw foods
- Increasing number of recalls
- Becoming a large issue
- Information required by industry/food producers – ILSI Europe report

In Preparation at present:

ILSI Europe Report on ‘Persistence And Survival Of Pathogens In Dry Food Processing

This Presentation

- **Review the issue**
- **Which pathogens**
- **Level of problem- controls**
- **Conclusions**

Low Moisture Foods

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- What are they?
  - Wide range
  - Animal feeds, cereals, chocolate, dried fruit, powders (egg, milk), herbs, spices, pasta, jerky/biltong, peanut butter, nuts/seeds
- Usually very stable, long shelf life products
- With stable microbiological flora

Which Pathogens ?

- Mainly enteric pathogens
- Salmonella - biggest issue at present-
- VTEC - has to be considered
- Cronobacter sakazakii - infant feeds
- Toxin producing Staphylococci - growth needed
- Toxin producing Bacillus – growth needed
- Aflatoxin producing Moulds - growth needed
- Viruses- Norovirus/HepA

Low Water Activity and Pathogens

- Using low Aw can provide a long shelf life
- Spoilage organisms grow slowly or are prevented from growing
- Pathogens are prevented from growing
- But if pathogenic organisms are present in high numbers, or the infective dose is low, then the risk to the consumer remains
- If low Aw ingredients are rehydrated during manufacture/preparation- growth can occur increasing risk to consumers

The Risk Realised- The Outbreaks

Almonds	S.Enteritidis	USA	2000	168
Almonds	S. Enteritidis	USA	2003	29
Almonds	S. Enteritidis	Sweden	2005	15
Cereals	S.Agona	USA	2008	28
Cereals	S.Agona	USA	1998	209
Chocolate	S.Eastbourne	UK	1985	95
Chocolate	S.Napoli	UK	1985	245
Chocolate	S.Typhimurium	Nor/Fin	1987	361
Chocolate	S.Montevideo	UK	2006	56
Coconut	S.various	Australia	1953	>50
Coconut	S.Java	UK	1999	18
Halva	S.Typhimurium	Aust/Eur	2001	>70
Infant feed	S.Ealing	UK	1985	76
Infant feed	S.Enteritidis	UK	1995	5
Marshmallow	S.Enteritidis	UK	1995	24

Outbreaks Associated with Dried Foods

• Peanuts	S.Mbandaka	Australia	1996	54
• Peanuts	S.Tennessee	USA	2006	628
• Peanuts	S.Typhimurium	USA/Can	2008	684
• Walnuts	E.coli O157	Canada	2011	13
• Hazelnuts	E.coli O157	USA	2011	7
• Pepper	S.Oranienburg	Norway	1981	126
• Pepper	S.Montevideo	USA	2010	>245
• Crisps/chips	S. various	Germany	1993	1000
• Infant feed	C.sakazakii	Iceland	1986	3
• Infant feed	C.sakazakii	USA	1988	4
• Infant feed	S.Tennessee	Can/USA	1993	3
• Infant feed	S.Anatum	UK	1996	12

Outbreaks Associated with Dried Foods

• Infant feed	C.sakazakii	Belgium	1998	12
• Infant feed	C.sakazakii	USA	2001	11
• Infant feed	S.Give	France	2008	8
• Power milk	S.Derby	Trinidad	1973	3000
• Salami	S.Newport	Australia	1981	279
• Salami	E.coli O157	USA	1994	4
• Salami	S.Typhimurium	Italy	1995	83
• Snack-corn	S.Manchester	UK	1989	47
• Snack-rice	S.Wandsworth	USA	2007	75
• Snack-sav	S.Agona	UK/USA/Israel	1994	>2200
• Tahini	S.Montevideo	Aust/NZ	2002	68
• Tea	S.Agona	Germany	2003	42
• Dried Tomatoes	Hep A	Aust/Europe	2009	<200

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Some Issues of Concern in Low Aw environments

- Infective Dose
- Protective effects of food
- Heat resistance characteristics

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Potential Infective Dose

- Can potentially appear to be very low in low Aw foods
- Organisms can be non-homogeneously distributed

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Salmonella Concentrations

S.Napoli	chocolate	<50 cells	(Greenwood 1983)
S.Typhimurium	chocolate	1 cell ingested	(D'Aoust 1994)
S.Heidelberg	cheddar cheese	100-500 cells	(Fontaine et al 1980)
S.Nima	chocolate	4-24 cells	(Hockin 1989)
S. Eastbourne	chocolate balls	2 -3 cells/g	(Craven et al 1975)

Salmonella Concentrations

S.Typhimurium PT10	Cheddar cheese	4.2 cells/g	(D'Aoust 1985 & 1989)
S. Oranienberg	Chocolate	2-3 cells	(Werber et al.2005)
S. Saintpaul S. Rubislaw S. Javiana	Chips + paprika	4-45 cells	(Lehmacher 1995)
S. Mbandaka	Peanut butter	3 cells/g	(Scheil et al 1998)
S.Ealing	Infant formula	1.6 /450g	(Rowe et al 1987)
S. Montevideo	Chocolate	0.3 /100g	(Independnt 2006)

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Protective effects of Foods on Salmonella

- Salmonella survive in low Aw foods
- Some interesting effects have been reported with multiple stresses
- As Aw falls below that needed for growth, Salmonella die slowly
- Rate of death decreases as Aw gets lower and as temperature reduces

Protective effects of Foods on Salmonella

Food	Temperature	Survival
Pasta	Ambient	1 log reduction in 90 - 360 days
Chocolate	Ambient	2 log reduction in19 months
Honey	10C	Survival for 2 years
Dry seasoning	22C	Survival for over 29 weeks
Peanut butter	21C	4 log reduction in 24 weeks

Protective Effects of Foods during Infection

- To cause food poisoning organisms must reach the small intestine
- To do this they must overcome the low pH in the stomach
- Many low Aw foods are high in fat or lipid
- Fat or lipid coating the cells may help cells survive a low pH environment

Heat Resistance- Salmonella

- **In media adjusted with sucrose**

Water Activity	D value (min) at 70 C
0.98	<0.05
0.94	0.3
0.90	0.6
0.89	0.99
0.85	2.8

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Heat Resistance-Salmonella

- In inoculated media/foods

Medium	Temperature	D value
BHIB	62C	24 sec
Milk	68.3C	0.3 to 0.5 sec
Whole egg	60C	183 sec
Ground beef	60C	27 sec
Chocolate	71C	4.5 to 20 h
Wheat flour	62C	14.6 h

Heat Resistance-Salmonella

- Heat resistance is very dependent on Aw
- Wheat flour 62C
- Aw 0.4, D 875 min
- Aw 0.5, D 100 min

What Foods Are a Problem Now- RASFF 2008-10

Organism	Food	No. Reports
Salmonella	Alfalfa seed	1
	Baby/infant food	3
	Buckwheat	1
	Chocolate	1
	Dried Sausage	1
	Dried fruit	3
	Grain	1
	Herbs & spices	14
	Nuts	11
	Protein supplement	4
	Sesame seed	14

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What Foods Are a Problem Now-RASFF 2008-10

Organism	Food	No.Reports
C.sakazakii	Infant formula	1
E.coli VTEC	Tea	2
E.coli	Herb	1
L.monocytogenes	Cake	1

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How to control the Issue in Production

- Consider points of entry for organisms
  - Raw materials/ingredients
  - Air
  - Water
  - Contact materials
  - Personnel
  - Pests

How to control the issue

- Reduction in contamination in raw materials
- Application of a process to raw material
- Prevention of recontamination
  - Use of zoning within production to separate wet & dry, high & low risk items
  - Personnel(all) & equipment must also be zoned
- Cleaning
  - Keep dry areas dry
- Care with dry mix ingredients- must be of high microbiological quality
- Monitor production environments- use zoning to focus sampling, and ‘indicator organisms’
- Consider and understand how products will be used
- Advise users of foods of the risk and measures to overcome it

Some Conclusions 1

- Survival of Pathogensin low Aw foods is a real food safety issue
- All dried foods can be affected

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Some Conclusions 2

- Reducing Aw increases heat resistance
- Reducing Aw increases survival time in food
- Some pathogens are infective at low dose in dry foods
- Some low Aw Foods may provide a protective effect in the stomach
- Care with low Aw ingredients that may be added to higher Aw ingredients, risks will increase
- Controls –
  - good quality raw materials
  - correct process
  - well designed production area using zones
  - keep dry areas dry
  - use well designed sampling plans to test production
- More information- ILSI Report available soon.

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