

# **Persistence and Survival of Pathogens in Low Water Activity Environments**

**Roy Betts**

**Campden BRI**

**Chipping Campden**

**UK**

**[r.betts@campden.co.uk](mailto:r.betts@campden.co.uk)**

# 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

- 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  $A_w$  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  $A_w$  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

# Some Issues of Concern in Low Aw environments

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

# Potential Infective Dose

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

# Salmonella Concentrations

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

# Salmonella Concentrations

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

# Protective effects of Foods on Salmonella

- Salmonella survive in low  $A_w$  foods
- Some interesting effects have been reported with multiple stresses
- As  $A_w$  falls below that needed for growth, Salmonella die slowly
- Rate of death decreases as  $A_w$  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 in 19 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  $A_w$  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

# 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  $A_w$
- Wheat flour 62C
  - $A_w$  0.4, D 875 min
  - $A_w$  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

# 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

# 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 Pathogens in low  $A_w$  foods is a real food safety issue
- All dried foods can be affected

# Some Conclusions 2

- Reducing  $A_w$  increases heat resistance
- Reducing  $A_w$  increases survival time in food
- Some pathogens are infective at low dose in dry foods
- Some low  $A_w$  Foods may provide a protective effect in the stomach
- Care with low  $A_w$  ingredients that may be added to higher  $A_w$  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.