



### Introduction to Microbiological Hazards and Controls in the Food Industry

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Introduction: Microbial Food Safety

- Microbial Hazards of Concern
- How consumers are at risk?
- How to protect consumers and control hazards?
- Risk management options









### On the loose..killer food bug that's unstoppable April 9, 2001



### ConAgra Serving Salmonella Pot Pies

orga

mayhave

13 November 2007

Salmonella in chocolate

June 24, 2006

**Deadly Spinach** A-channel news

E COII O 157 KIIIS FINO **Supermarket** recalls salad nay Bug. packs in salmonella scare

The Scotsman, 28 April 2007

Killer Cucumbers! E.coli STEC

Beef Kills A Three

Year-Old Girl,

May-June 2011



Food











- 48 million illnesses
- 3,000 deaths annually due to food pathogens
- one out of every six Americans : foodborne illness each year.

www.cdc.gov/foodborneburden/2011-foodborne-estimates.html.

#### The cost of this to the United States is \$152 billion per year.

www.producesafetyproject.org/admin/ assets/files/Health-Related-Foodborne-Illness-Costs-Report.pdf-1.pdf.



### Food Poisoning Outbreaks: India



Year	No. of outbreaks	No. of cases	No. of deaths
2009 (June to Dec.)	58	4703	35
2010	186	10765	101
2011	302	14790	90
2012 (up to June)	160	8065	41







Source: Integrated Disease Surveillance Project. www.idsp.nic.in





### Micro-organisms of concern?



#### The Good, the Bad, the Ugly

- **Good**-Fermentative Microbes
  - (bacteria, yeasts/fungi)
- Bad-Pathogens
  - (bacteria, viruses, parasites, fungi)
- Ugly-Spoilage
  - (bacteria, fungi)









### Bacteria



- Salmonella (Typhoidal and nontyphoidal)
- Listeria monocytogenes
- Escherichia coli
- Campylobacter spp
- Aeromonas spp
- Vibrio spp
- Yersinia enterocolitica
- Staph. aureus
- Clostridium perfringens
- Clostridium botulinum









Rotavirus Norovirus Sapovirus Adenovirus Astrovirus Coronavirus Hepatitis A Hepatitis E



















### Which Pathogens are Important?



Country	Viral Infectio ns ( 10 <sup>3</sup> )	Bacterial infections ( 10 <sup>3</sup> )	Bacterial Intoxicati ons ( 10 <sup>3</sup> )	Parasitic infections ( 10 <sup>3</sup> )	Burden of viral illness	Source	
USA	9200	3715	460	357	1 in 33	Mead et al., 1999	
Australia	470 (95% CI) 210–740	886 (95% CI) 590–1310	64 (0-86)	66 (18-114)	1 in 43	Hall et al., 2005	
Nether- lands	90 (50–130)	283 (82–146)	114 (35–236)	25 (0–50)	1 in 178	DeWit et al., 2003 Kreijl et al., 2006	
UK	77 (70 <del>-84)</del>	659 (510–807)	221 (98–345)	4 (4–5)	1 in 780	Adak, Long and O'Brien, 2002	/
Japan	13.5 (95%CI)- 3.4-23.6	12.7 (95% CI) 8.8–16.6	1.8 (95% CI) 1.4–2.2	No data available	1 in 9333	Report Ministry of Health, Welfare and Labour	

Source: FAO/WHO (2008) Viruses in food :scientific advise to risk management activities





#### Estimated number of patients (year/USA, Mead et al. 1999)

23 million Noroviruses Campylobacter 2,5 million Salmonella 1,4 million 450.000 Shigella 300.000 Cryptosporidium 185.000 St. aureus L. monocytogenes 2.500 









#### Reported Foodborne Outbreak-associated Hospitalizations, by Cause\* – United States, 2008

Etiology (Cause)	Number
Salmonella	797
Escherichia coli, Shiga toxin-producing	214
Campylobacter	25
Staphylococcus enterotoxin	12
Clestridium botulinum	-
Listeria	25
Other bacterial	9
Chemical and toxin	15
Parasitic	2
Norovirus	90
Other viral	4
Multiple etiologies	34
Total	1,276

 If at least one etiology was laboratory-confirmed, the outbreak was considered to have a "confirmed etiology". If no etiology was lab-confirmed, but an etiology was reported based on clinical or epidemiologic features, the outbreak was considered to have a "suspected etiology".





### Which Foods act as Vehicle?



- Campylobacter
- Salmonella
- *E. coli 0157*
- L. monocytogenes
- Staph. aureus
- Clostridium perfringens
- Viruses
- Parasites

Chicken/eggs, vegetables

Beef

Chicken

cheese, smoked fish, cooked meats

Dairy products (sweets)

#### Meat

shellfishes, vegetables

vegetables, fishes, beef/pork









Factors contributing to consumer risk Microbial Factors

- Invasiveness
- Pathogenicity
- Virulence
- Infectious dose
- Viability in the free state
- Host specificity
- Antigenic variation
- Ability to develop resistance to antimicrobial agents





Microbial Factors Contd.....

Micro-organism	Illnesses (%)	Hospital. (%)	Death (%)
Bacillus cereus	0.198	0.014	0
Staph. aureus	1.3	2.9	0.107
Yersinia enterocolitica	0.628	1.8	0.126
CI. botulinum	0.00042	0.076	0.246
CI. perfringens	1.8	0.064	0.360
Vibrio	0.038	0.203	1.7
E. coli (path.)	1.3	4.6	4.3
Campylobacter	<u>14.2</u>	<u>17.3</u>	5.7
L. monocytogenes	0.018	3.8	<u>27.5</u>
Salmonella	9.7	<u>25.7</u>	<u>30.4</u>





#### **Consumer Factors**

- Age
- Socioeconomic status
- Disease history
- Lifestyle
- Heredity

- Immunization status
- Medications
- Pregnancy
- Trauma
- Nutritional status



#### How are consumers exposed?



### YOPI's are the most vulnerable

#### Consumer Factors contd......

# very Youngvery Old









### Pregnant

Immuno-compromized



#### How are consumers exposed?



#### **Primary contamination**

Diseased animal Plant source contamination







#### **Secondary contamination**

- Equipment/ transport vehicle
- Water
- Soil
- Air
- Waste
- Packaging
- Pet/wild animals
- People















### How to protect consumers?





#### How to protect consumers?



#### Barriers on three levels

### Primary production

#### Processing

















## Control strategies to assure safety of the final product

- Hazards need to be controlled to acceptable levels at all three levels
  - Prevent
  - Eliminate
  - Reduce
  - Avoid unacceptable growth and survival
  - Prevent spread and contamination











Control options at all levels must consider:

- Food formulation and composition
  - Raw materials & ingredients?
  - Processing
    - Inactivation, growth opportunities?
- Packaging
  - Cross-contamination possible?
- Distribution
  - Growth possible?
  - Consumer use / abuse
    - Growth, incomplete inactivation?









Different option(s) may apply for different foods, e.g. for prevention of botulism

- Eliminate
- Reduce
- Prevent
- \* 12D-concept vegetables, meat products Aw < 0,93 vegetables, meat products \* pH < 4,6 vegetables, meat products Nitrate/nitrite meat products \* \* NaCI (salt) meat products, smoked fish \* Refrigeration vegetables, vegetables, meat products, smoked fish

### **Risk Management Options**



#### **Governmental responses : Unsafe foods**

- Prohibiting marketing of the foods (e.g. recall)
- Mandatory enforcement of microbiological criteria
- Defining process criteria for key food supply chain operations
- Requiring import certificates
- Carrying out educational programs
- Setting an FSO





### Risk Management Options



#### Where do we draw the line?

- Standard
  - A microbiological criterion which is part of a law or regulation. A mandatory criterion enforceable by the regulatory agency having jurisdiction

#### Guideline

 Advisory criterion that may be established by regulators, industry or trade associations when best practices are applied to manufacture safe foods

#### Specification

• Microbiological criterion which is applied as a condition of acceptance of a food or ingredient by a food manufacturer or public or private agency. *Mandatory* in supplier-buyer relationship.







#### Governments may mandate limits for safety (/hygiene)

European Commission	Aerobic mesophilic bacteria	M = 100000	Point of production
Greece	Aerobic mesophilic bacteria	M = 100000  per  1  g	Not specified
Codex Alimentarius	Aerobic mesophilic bacteria	m = 50000 M = 1000000	end-product
South Africa	Aerobic mesophilic bacteria	20000	Retail
Netherlands	Aerobic Plate Count @ 30°C	<100000	Point of production / retail
Codex Alimentarius	Coliforms	m = 10 M = 100	end-product
South Africa	Coliforms	50	Retail
European Commission	Enterobacteriaceae	M = 100	Point of production
South Africa	Moulds	200	Retail
Greece	Pathogenic bacteria or toxins	Not detectable	Not specified
Codex Alimentarius	Salmonella spp.	m = 0	end-product
European Commission	Salmonella spp.	Not detectable in 25g or 25ml	Point of production
Greece	Salmonella spp.	Not detectable in 25g	Not specified
Netherlands	Staphylococcus aureus	Not detectable in 1g	Point of production / retail
European Commission	Staphylococcus aureus	Not detectable	Point of production
France	Staphylococcus aureus	m = 500	Not specified
Greece	Total mesophilic flora	<100000	Not specified
South Africa	Yeasts	200	Retail





#### Limits may be implemented through Sampling plans (ICMSF)

	Conditions in which food is expected to be handled and			
	consumed after sampling in the usual course of events			
Degree of concern	Conditions reduce	Conditions cause	Conditions may	
relative to utility and health hazard	degree of concern	no change in concern	increase concern	
Moderate hazard;	Case 7	Case 8	Case 9	
direct, limited spread	3-class <b>n=5, c=2</b>	3-class <b>n=5, c=1</b>	3-class <b>n=10, c=1</b>	
Serious hazard;	Case 10	Case 11	Case 12	
incapacitating but not usually life threatening sequelae are rare, moderate duration	2-class <b>n=5, c=0</b>	2-class <b>n=10, c=0</b>	2-class <b>n=20, c=0</b>	
Severe hazard; for (a)	Case 13	Case 14	Case 15	
the general population or (b) restricted	2-class <b>n=15, c=0</b>	2-class <b>n=30, c=0</b>	2-class <b>n=60 c=0</b>	
life-threatening or substantial chronic			C Ms I + F	
long duration				





#### Cereal-based foods for infants

Microorganism	n	С	m	Μ
<i>Bacillus cereus</i> / g	5	1	10 <sup>2</sup>	10 <sup>3</sup>
<i>Clostridium perfringens</i> / g	5	1	10	10 <sup>2</sup>
Coagulase-positive staphylococci / g	5	1	10	10 <sup>2</sup>
<i>Listeria monocytogenes / 25</i> g	5	0	0	
Standard Plate Count / g	5	2	10 <sup>3</sup>	104

Microbiology AS / NZS 1766 or validated alternative method (AS/NZS 4659)





### Indian Standards



Frozen meats				
Characteristic	Requirements			
Fotal plate count	10000/g			
E.coli	100/g			
Staph aureus	100/g			
Cl. perfringens and Cl. botulinum	30/g			
Salmonella	Absent in 25 g			
Listeria monocytogenes	Absent in 25 g			

Corned beef, luncheon meat, cooked ham, canned meat

Characteristic	Requirements
Total plate count	1000/g
E.coli	Absent in 25 g
Staph aureus	Absent in 25 g
Cl. perfringens and Cl. botulinum	Absent in 25 g
Salmonella	Absent in 25 g





WHO suggested three principal lines of action

- Advocating and supporting the development of riskbased, sustainable, integrated food safety systems
- Devising science-based measures along the entire food production chain that will prevent exposure to unacceptable levels of microbiological agents and chemicals in food
- Assessing and managing foodborne risks and communicating information, in cooperation with other sectors and partners.

Source: Global strategy for food safety: Safer food for better health. http://www.who.int/fsf





# Identify and characterize food safety risks: Risk Assessment

- Hazard identification
- Hazard characterization
- Exposure assessment
- Risk characterization
- Minimize and manage risks in food production chain: Risk Management
  - Farm level: GAP, GAHP
  - Transportation: GHP
  - Factory/processing: GMP, GHP, HACCP
  - Microbiological standards/recall: Policies
- Education and awareness of all the stakeholders: Risk Communication
  - Mass-media campaign
  - Training and education: Food handlers and other stakeholders

