Interventions to Control Microorganisms in Spices

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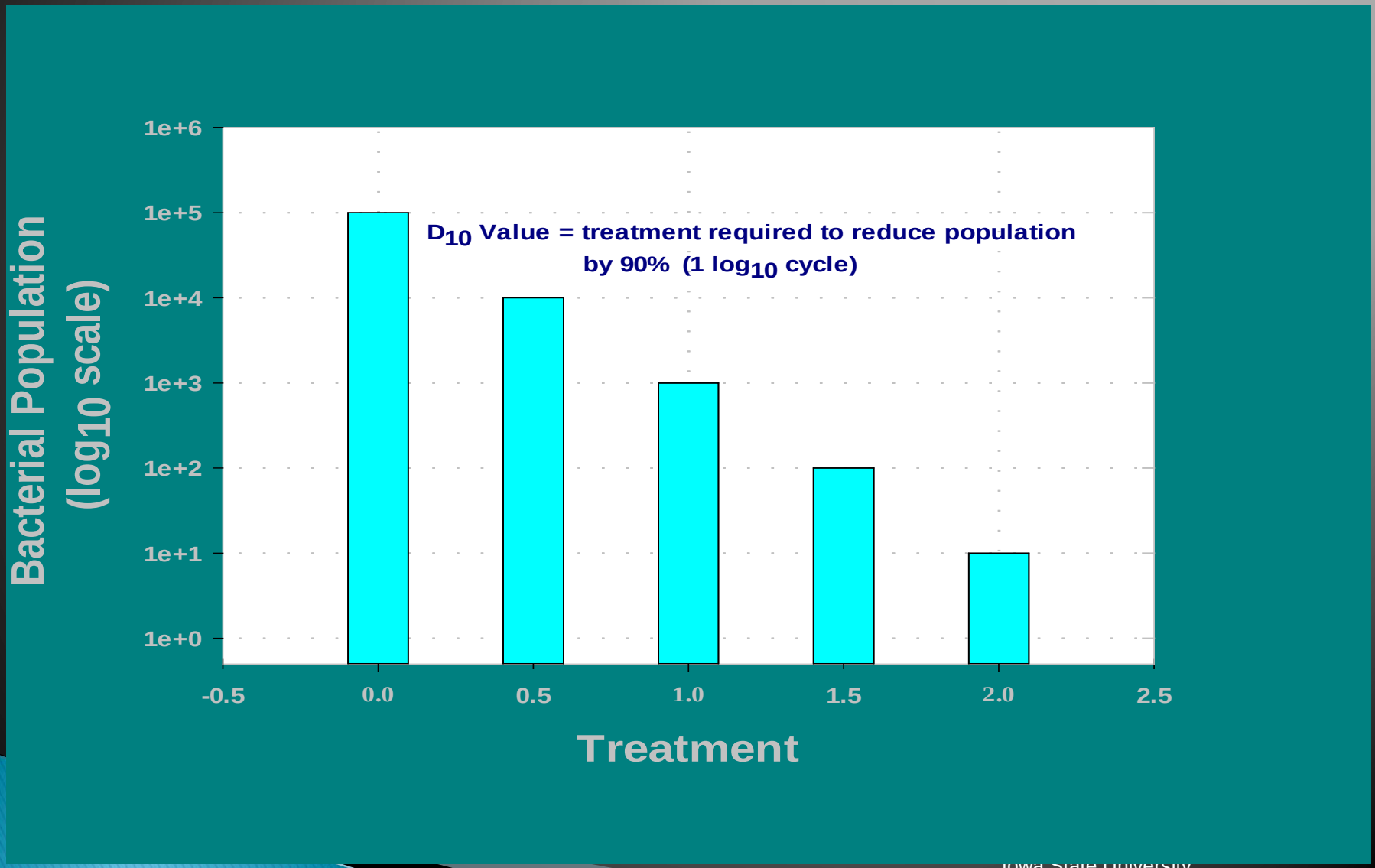
Basic Principles

- Basic Principles
- Types of Interventions
  - Physical
  - Thermal
  - Chemical
  - Radiation
- Validation

Decimal Reduction Values

- **Referred to as "D_{10}" or "D" values.**
- **The amount of treatment or process which results in a 90% (1 $\log_{10}$) reduction in microbial population**
  - **100,000 ⇒ 10,000 = 1 D_{10} Reduction**
  - **100,000 ⇒ 100 = 3 D_{10} Reduction**

Decimal Reduction Values



Decimal Reduction Values in Processing

- **Usually based on probabilities**
- **For example – A process which accomplishes a 5 D_{10} (5 $\log_{10}$) in the population of salmonellae**

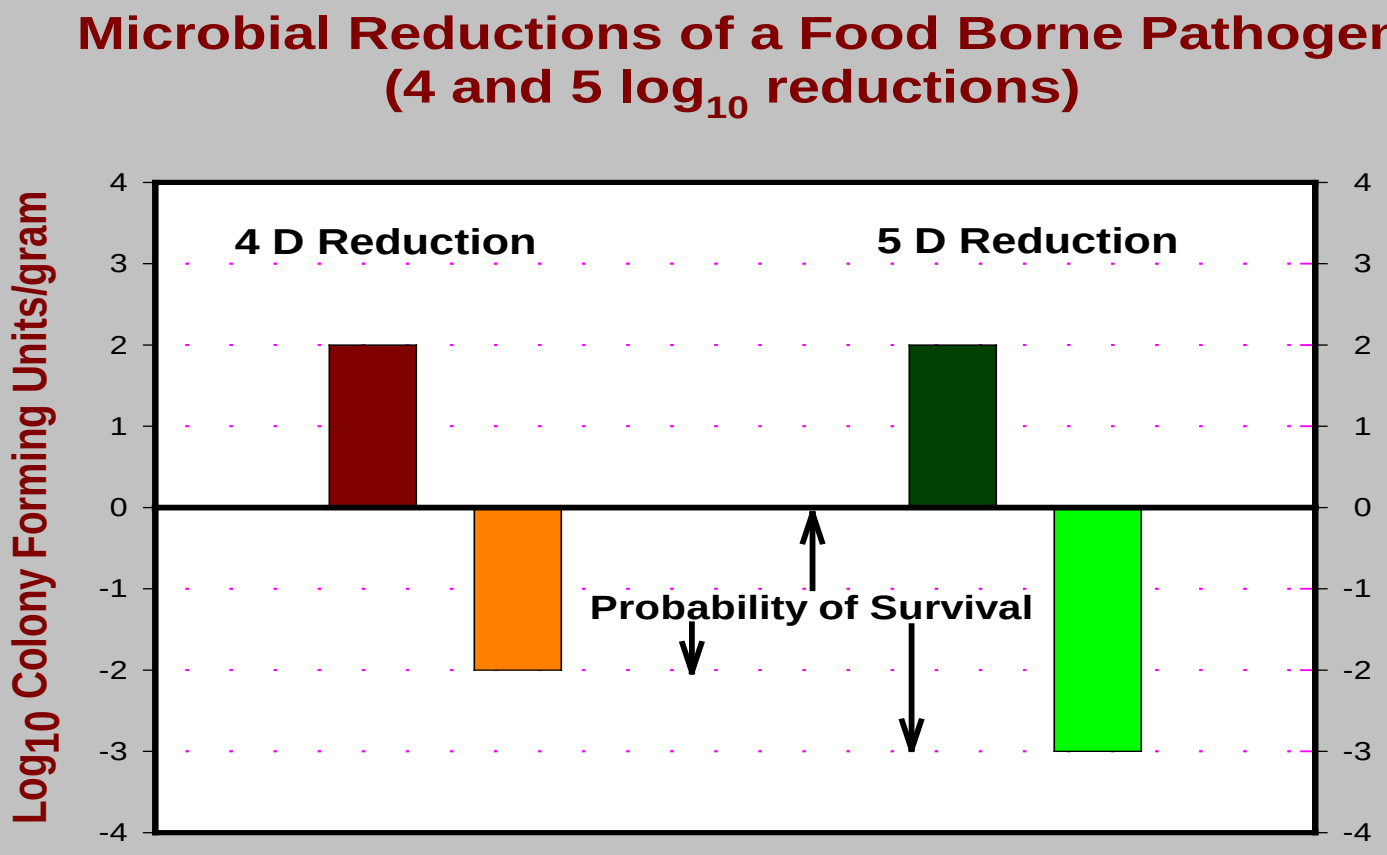
A. **We do not expect 5 $\log_{10}$ (100,000) salmonellae per gram**
B. **Process provides a margin of safety**

Probability

- **In every process, there is a probability that**

A. **the intended result will happen**
B. **the intended result will not happen**

Processing


Microbial Reductions of a Food Borne Pathogen
(4 and 5 log10 reductions)
Log10 Colony Forming Units/gram
4 D Reduction
5 D Reduction
Probability of Survival
4
3
2
1
0
-1
-2
-3
-4

Processing Regulations

- **Used to establish guidance for equivalent processes**
- **Sets a process objective, and allows the processor to use different methods to achieve a specific objective**
- **US FDA will often require a process which accomplishes a 5 $\log_{10}$, or 5 D_{10} reduction in the population of salmonellae.**
- **FDA does not currently have a specific requirement for spices**

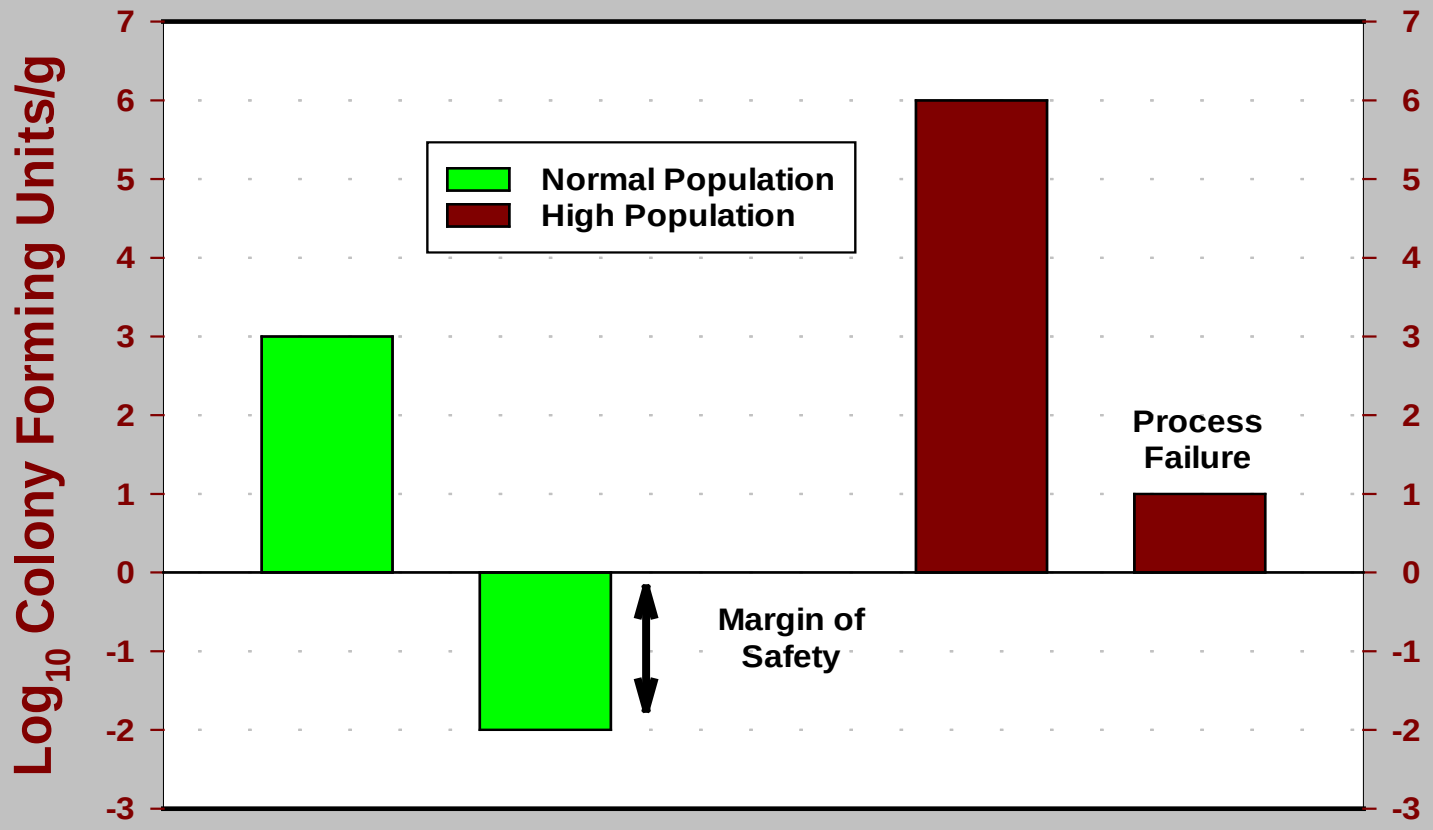
Quality of Incoming Spices affects the Results

- **Any process can and will fail if the population exceeds the ability of the process to eliminate it.**

- **The microbiological quality of the incoming spices has a profound impact on the result of the process**

Processing

5 $\log_{10}$ Reduction (5D) of a Bacterium
Effect of Initial Population



Disclaimer

- **Photographs used in this presentation are only to illustrate examples of specific types of equipment.**

- **Use of a specific illustration or company reference *DOES NOT CONSTITUTE* an endorsement of any equipment, service or company.**

Mechanical Methods

Mechanical Methods

- **Usually thought of as means of removing foreign material**
- **Foreign material often heavily contaminated with bacteria**
  - **Gravity Separators**
  - **Sieves**
  - **Air (“cyclone”) separators**

Mechanical Methods

- **While not usually considered as an intervention, mechanical removal of foreign material often lower the microbial population in the spices**

Processing Conditions

- **Particle size**
- **Particle Density**

Physical Methods

Physical Methods

- **Thermal Processes**
  - **Steam**
  - **Dry heat**

Physical Methods – Mechanism

- **Vegetative Cells:**
  - **Denaturation of proteins**

- **Spores:**
  - **Denaturation of proteins (much more resistant than vegetative cells)**

http://phil.cdc.gov

Processing Conditions

- **End Point Temperature**
- **Exposure time**
- **Moisture Content:**
  - **Lower a_w's result in greater heat resistance**
  - **D_{10} Value of Bacillus cereus spores**
  - **95°C; $a_w = 1.00$ D_{10} = 2.38 minutes**
  - **95°C; $a_w = 0.95$ D_{10} = 5.01 minutes**
  - **95°C; $a_w = 0.86$ D_{10} = 13.84 minutes**

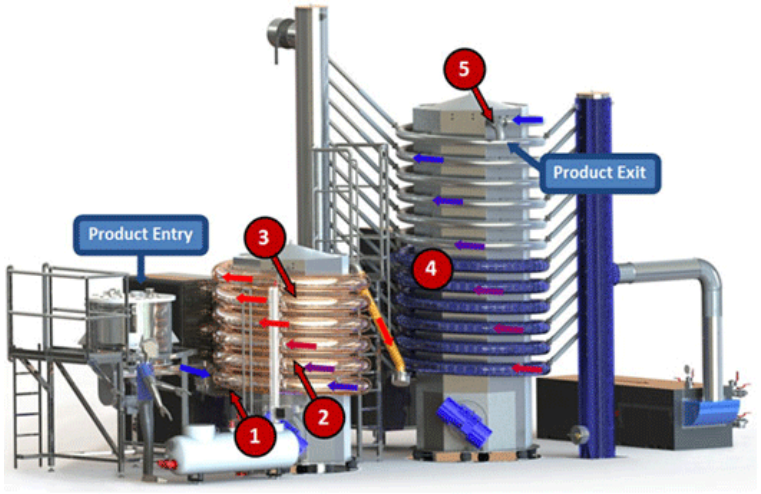
Processing Conditions

- **Considerable variability in the processing conditions**
- **May be continuous or batch process**
- **May be smaller, self contained system or larger system**
- **May be self-owned or fee-for-service contractor**

Processing Conditions

- **Spices are rapidly heated and then rapidly cooled**
- **May include a drying step if steam is used as a heat source**

Processing Conditions



1. The product is fed in the spiral tube at a constant flowrate.

2. The product is heated up by direct contact with the hot tube and progresses inside the tube under the effect of the vibrations of the tube.

3. A very small amount of steam (between 3 and 10%) is then injected to highly reduce the remaining micro-organisms, preserving the organoleptic properties of the product

4. The product is stabilized and cooled down in the second spiral tower by cold, dry and filtered air

5. The product exits at ambient temperature ready for packing

http://www.revtech-process-systems.com/index.php/en/pasteurization-herbs-and-spices

http://www.itcspices.com/Spices/ManageContent/ContentView.aspx?ContentID=9

Chemical Methods

Chemical Methods

- **Gas or fumigants**
  - **Ethylene Oxide**
  - **Propylene Oxide**

- **Ozone??**

Chemical Methods – Mechanism

- **Vegetative Cells:**
  - **binds to proteins and prevents enzymes from being active**
  - **Stops energy production**
  - **Cell dies when energy reserves are exhausted**

- **Spores:**
  - **Binds to specific nucleobases within the DNA**
  - **Interferes with the germination of the spore and development of the cell**

Processing Conditions

- **Concentration of gas**

- **Exposure:**
  - **Time**
  - **Temperature**
  - **Humidity**
- **Example:**
- **Clostridium botulinum spores**
- **700 mg/l, *47% RH* – D_{10} value 11.5 minutes**
- **700 mg/l, *23% RH* – D_{10} value 7.4 minutes**

Processing Conditions

- **Breathable containers**
  - **Allow gas to penetrate product**
  - **Processing time has to account for penetration into the center of the container**

- **Maximum Residual Level:**
  - **US EPA regulation: 7 ppm EtO**
    - **940 ppm (reaction products)**
  - **Other countries have different standards**
  - **NOTE: The EU has banned EtO processing.**

Processing

http://www.etcsterilization.com/wp-content/themes/Foundation-master/images/eo-sterilizer-sm.jpg

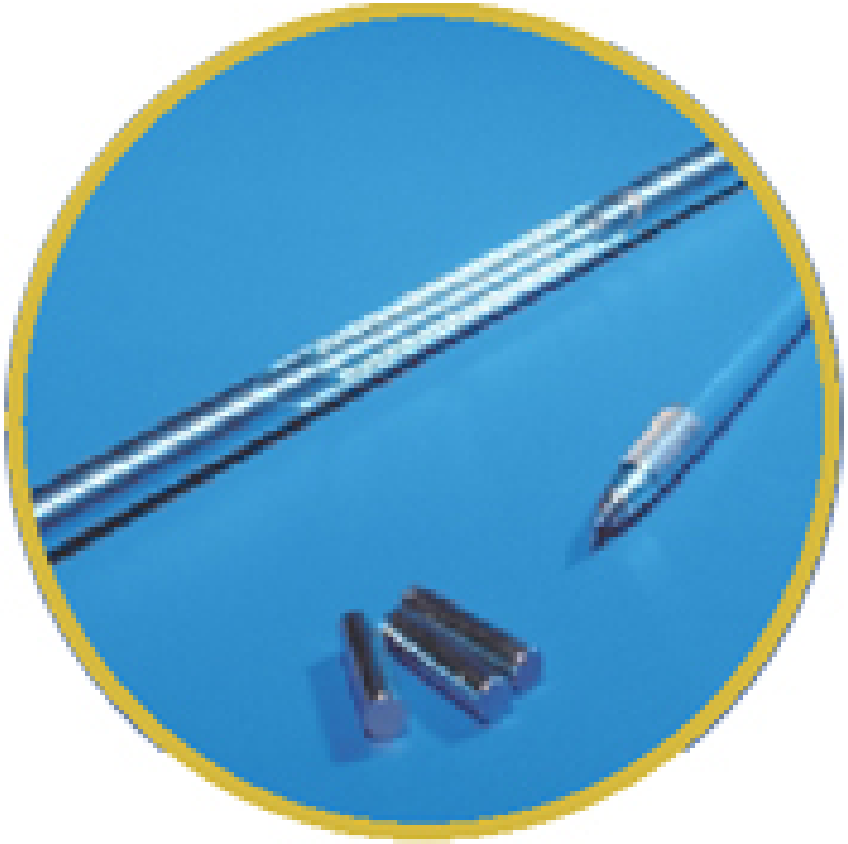
- Heavily regulated process in the US
- Potentially hazardous to employees
- Often performed by fee-for-service contractors

Chemical Methods

- ISO 11135-1-2007
  - Sterilization of health care products – Ethylene oxide – Part 1: Requirements for development, validation and routine control of a sterilization process for medical devices
- **ISO/TS 11135-2-2008**
  - **Sterilization of health care products - Ethylene oxide - Part 2: Guidance on the application of ISO 11135-1**

- Radiological

Irradiation

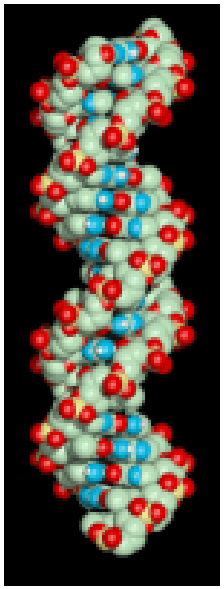


- $Cobalt^{60}$
- typically loaded to 250,000 curies
- $Cesium^{137}$ used less commonly
- slightly soluble in water

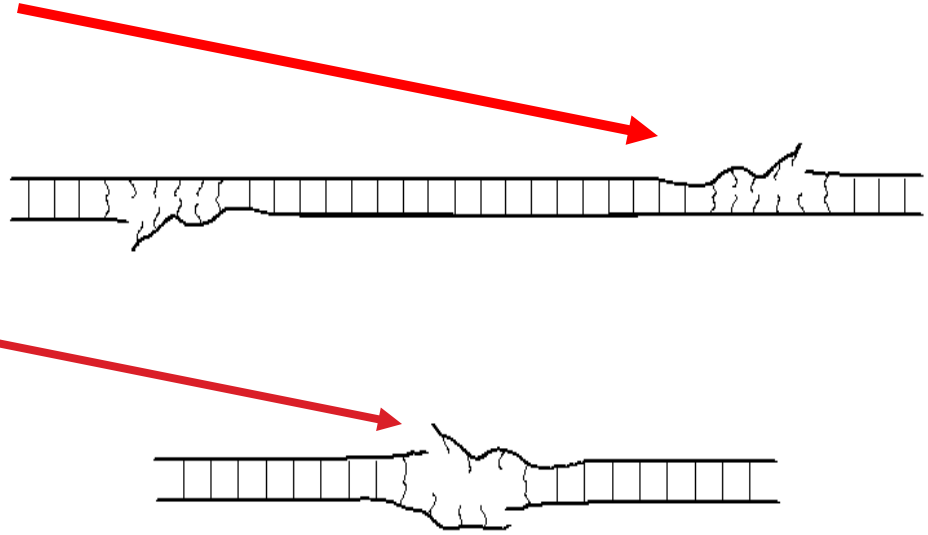
Irradiation
Units and Doses

- **Measured as Absorbed Dose - gray (Gy) or kiloGray (kGy)**
- **Older unit of measure – "Rad"**
  - **100 Krad = 1 kGy**
  - **1 Mrad = 10 kGy**

Irradiation Modes of Action



- Direct ionization of nucleic acids
- Lesions produced in genetic material
- single stranded breaks are repairable (may cause mutations)
- double stranded breaks are lethal



www.pnl.gov/berc/bg/fatal_lesion.html

Processing Conditions

- **Absorbed Dose:**
  - **US FDA: Spices – 30 kGy (maximum)**
  - **D_{ur} – Dose Uniformity Ration**
  - **(Maximum to Minimum Dose ratio)**

- **Temperature:**
  - **Bacteria more resistant at lower temperatures**

- **Moisture Content:**
  - **Bacteria more resistant at lower a_w's**

Dose Distribution

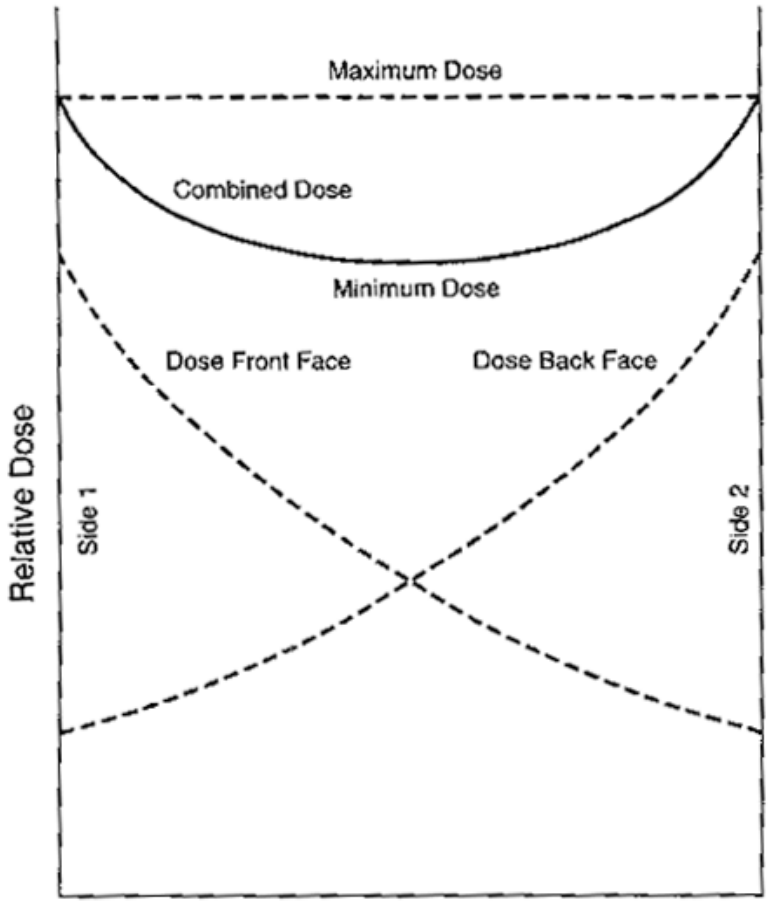
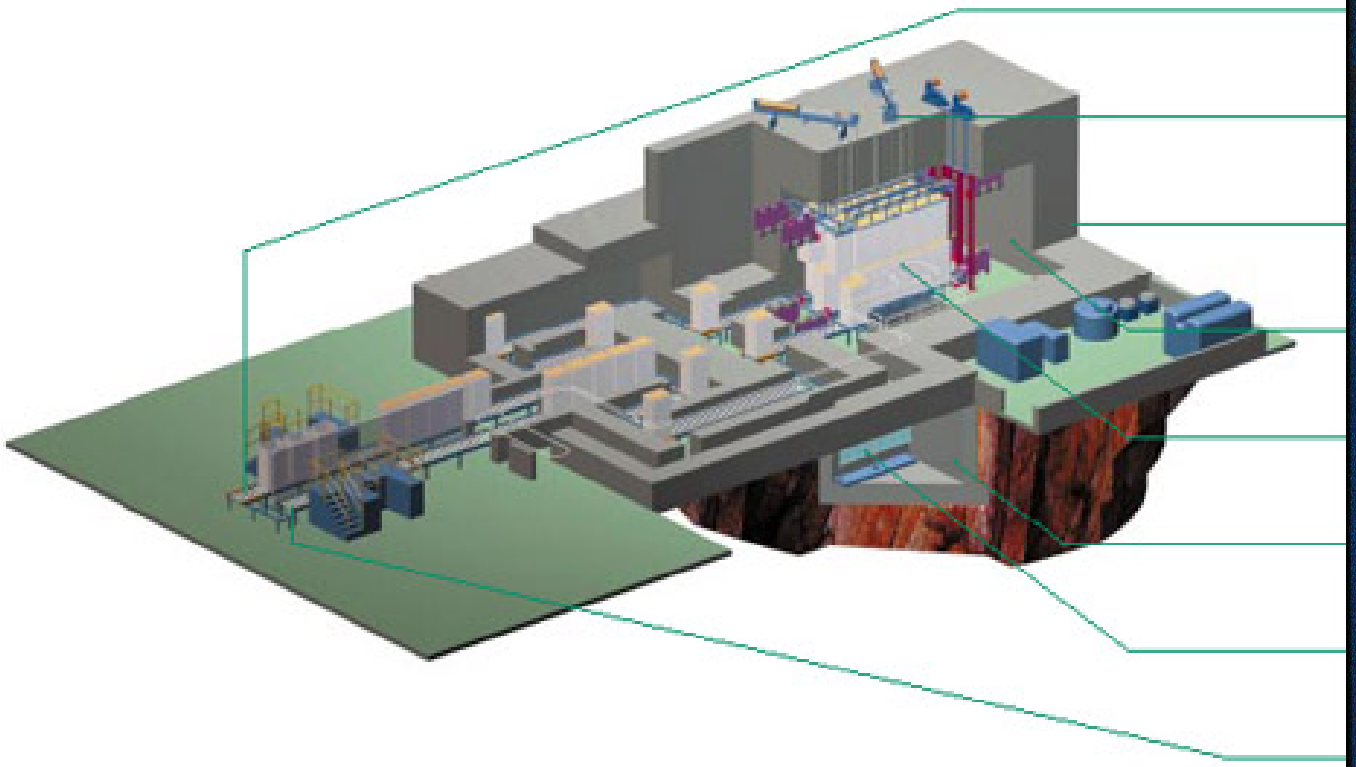


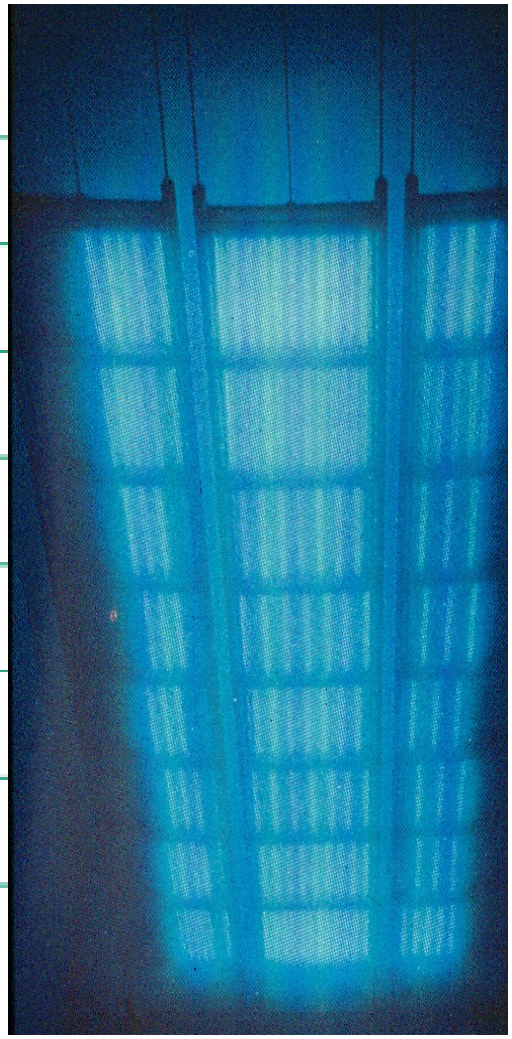
FIGURE 1.4. General x-ray or cobalt-60 depth-dose distribution in water for two-sided irradiation.

Destruction of Bacteria

Organism	D_{10} Value (kGy)
Salmonella	**0.55 – 0.70**
Listeria	**0.40 – 0.64**
Clostridium	
Vegetative cells	**0.30**
Spores	**3.50**

Irradiation Processing





Irradiation Processing

- **Heavily regulated process in the US**
- **Potentially hazardous to employees**
- **Often performed by fee-for-service contractors**

ISO Standard

- **ISO 14470**
- **Food irradiation — Requirements for the development, validation and routine control of the process of irradiation using ionizing radiation for the treatment of food**

ISO 14470

- **Similar to:**
  - **ISO 11137-1:2006**
  - **Sterilization of health care products – Radiation**

Codex Standards

- **GENERAL STANDARD FOR IRRADIATED FOODS CODEX STAN 106-1983, REV.1-2003**

- **CODE OF PRACTICE FOR RADIATION PROCESSING OF FOOD CAC/RCP 19-1979, Rev. 1-2003**

Dosimetry

- ASTM 2302 -11; Standard Guide for Absorbed-Dose Mapping in Radiation Processing Facilities
- ISO/ASTM 51204:2004; Standard Practice for Dosimetry in Gamma Irradiation Facilities for Food Processing
- ISO/ASTM 51261:2002; Standard Guide for Selection and Calibration of Dosimetry Systems for Radiation Processing

Label & Material Regulations

- **Labeling**
  - ❖ **Retail**
    - Radura, plus “Treated by Irradiation”
    - “Irradiated for food safety” most popular
    - If treated product used as an ingredient, identify in Ingredient Statement
  - ❖ **Foodservice**
    - On case to establishment
    - No requirement to inform consumer

Verification and Validation

Definitions

- **Verification – was the process performed as described?**
- **Validation – did the process accomplish the technical objective?**

ISO Standards

- **Existing standards for EtO and Irradiation**
- **Sections on Operational Qualification and Performance Qualification**

Validation

- **Current research ongoing (funded by ASTA and ILSI) to develop non-pathogenic surrogates which can be used to validate steam, gas and irradiation processes.**

Questions?