Microbiology of Spices

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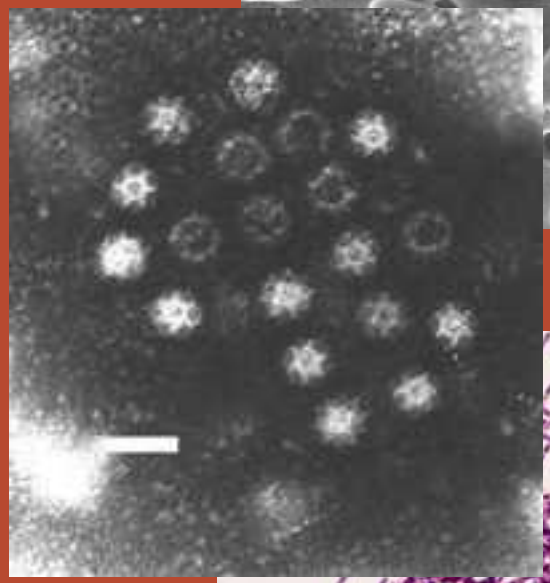
Part 1
Review of Basic Microbiology

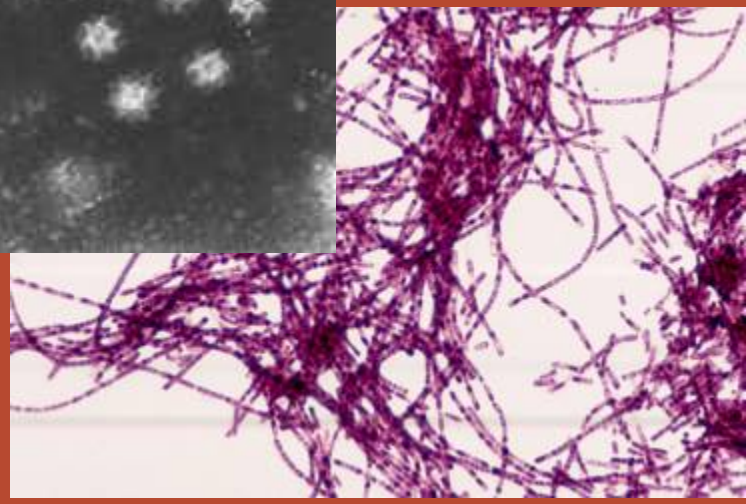
Outline – Part 1

- Review type of microorganisms
- Overview of the microbiology of spices
- Foodborne Illnesses

Microorganisms

- Most micro-organisms are harmless
- Many are helpful
- Very few cause disease





Outline – Part 2

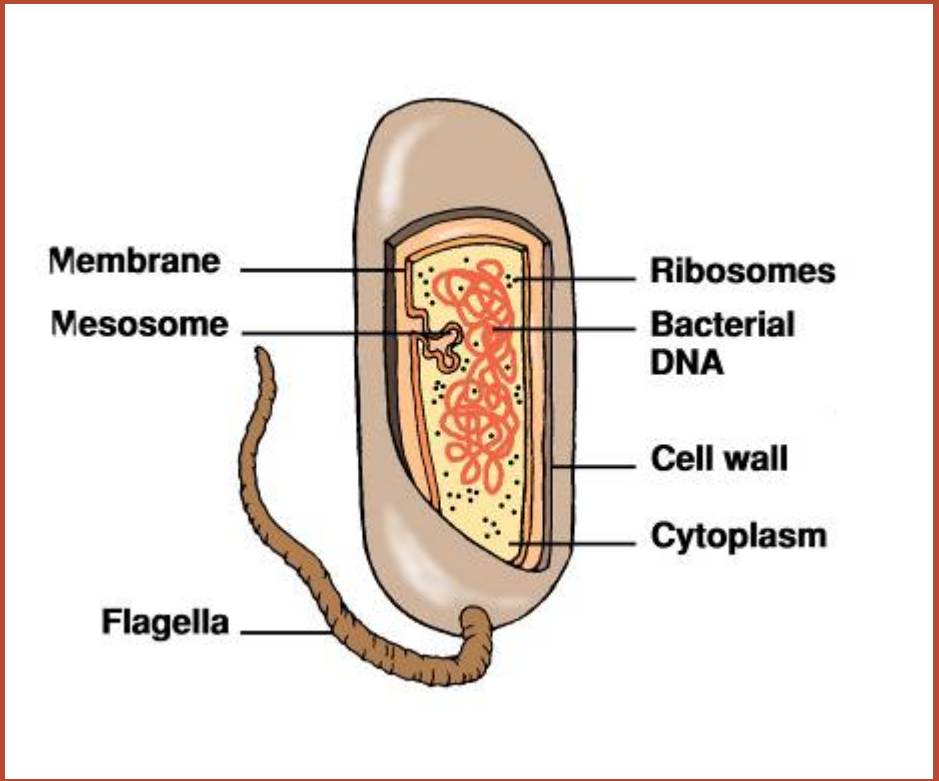
- Basic outline of microbial testing methods
- Spice production and processes.
- Interventions
- Verification and Validation

Microorganisms Important in Foods

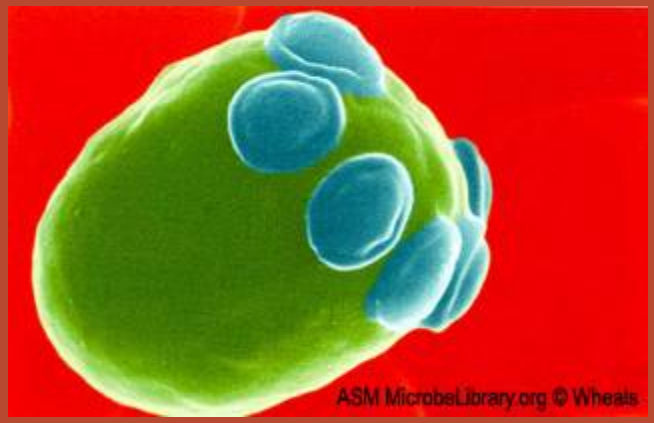
- Bacteria
- Fungi (yeasts and molds)
- Viruses

Bacteria

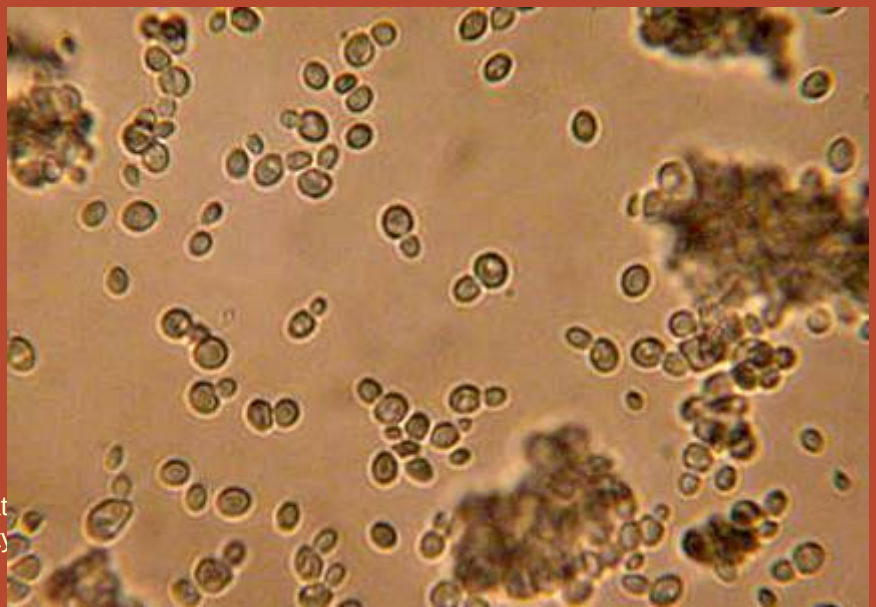
- Largest group of microorganisms
- Most important group from a food microbiology perspective

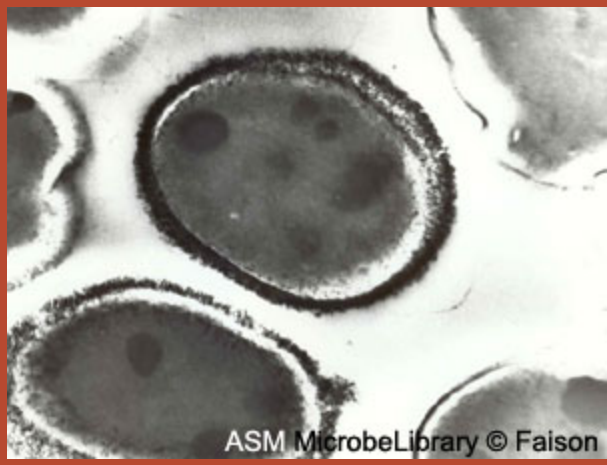


Yeasts



- Single celled
- usually round or oval
- require simple diets
- can grow with or without oxygen





Yeasts

- Ferments sugar to:
  - Alcohol
  - carbon dioxide

- Grow with or without oxygen
- Grow slower than most bacteria
- Grow in environments that most bacteria will not grow in

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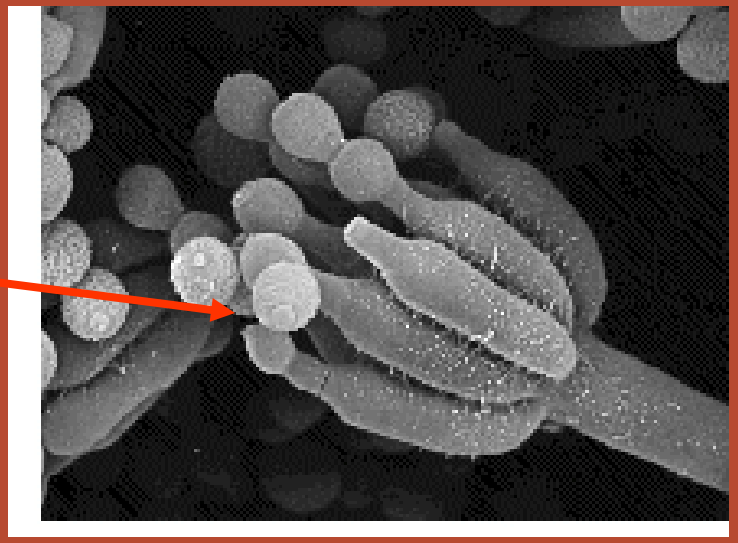
Molds

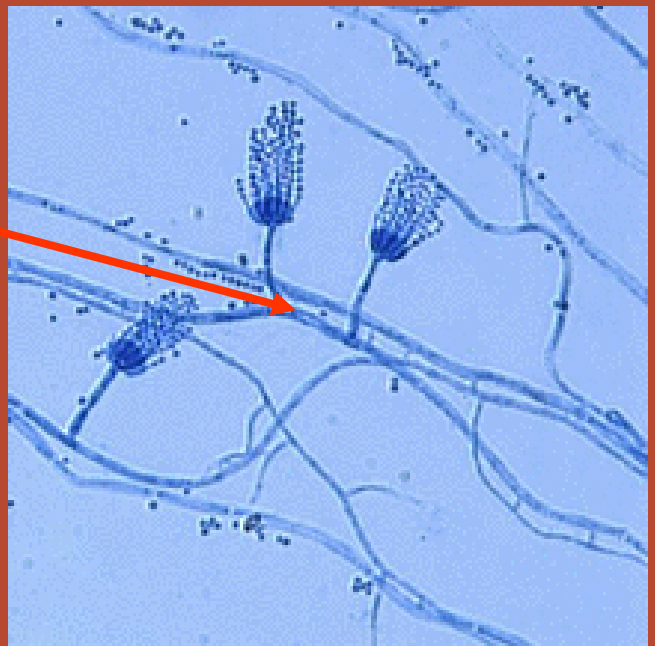
- Visible mold is actually a colony
- Made up of multiple types of cells
- requires oxygen for growth

Molds

- Reproductive cells

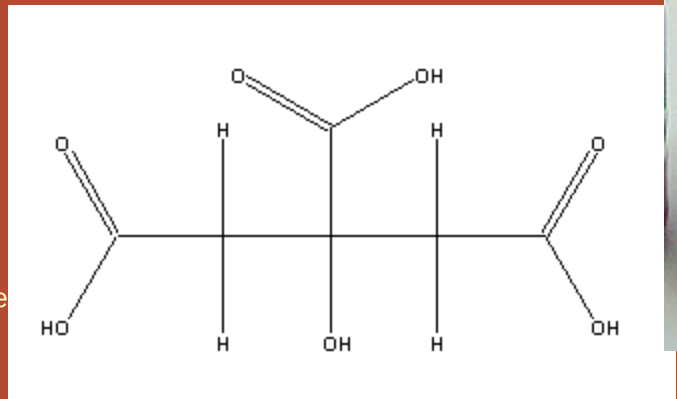


- Vegetative cells



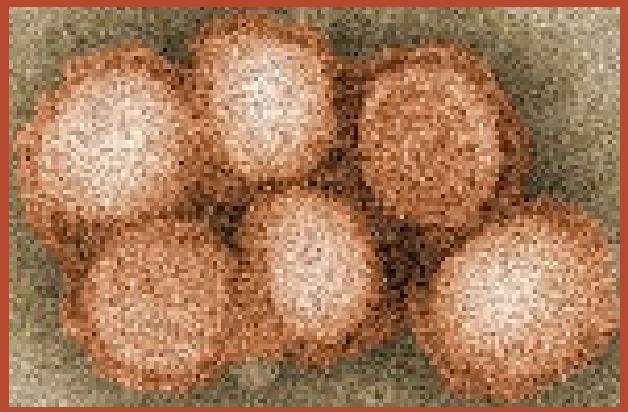
Molds

- Products include
  - mold ripened cheese
  - soy sauce
  - Enzymes
  - citric acid



Viruses - Physiology

- Obligate intracellular parasites
- no metabolic activity
- can infect bacteria (bacteriophage) plants, animals and humans
- in general, viruses are species speific



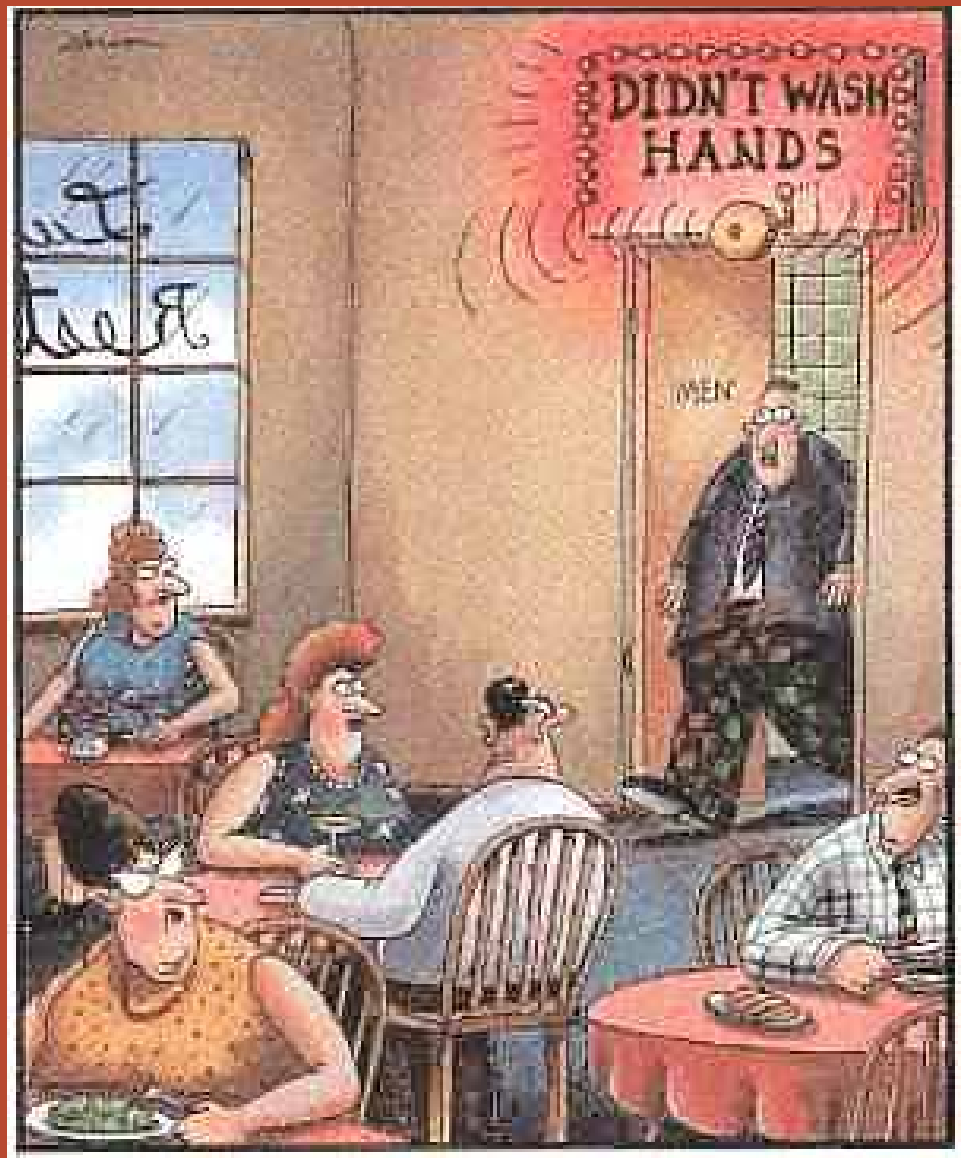
http://s.ph-cdn.com/newman/gfx/news/hires/2012/influenza.jpg

Viruses - Reproduction

- Virus attaches to host cell
- insertion of viral genetic material (either RNA or DNA) into host cell DNA
- host cell manufacturers new virus
- cell lysis, virus particles released

Enteric Viruses

- **Human viruses do not replicate in environment**
- **food, water, air or utensils are simply the vehicle for transmission**
- **very low infective dose**



Factors Affecting Microbial Growth and Survival

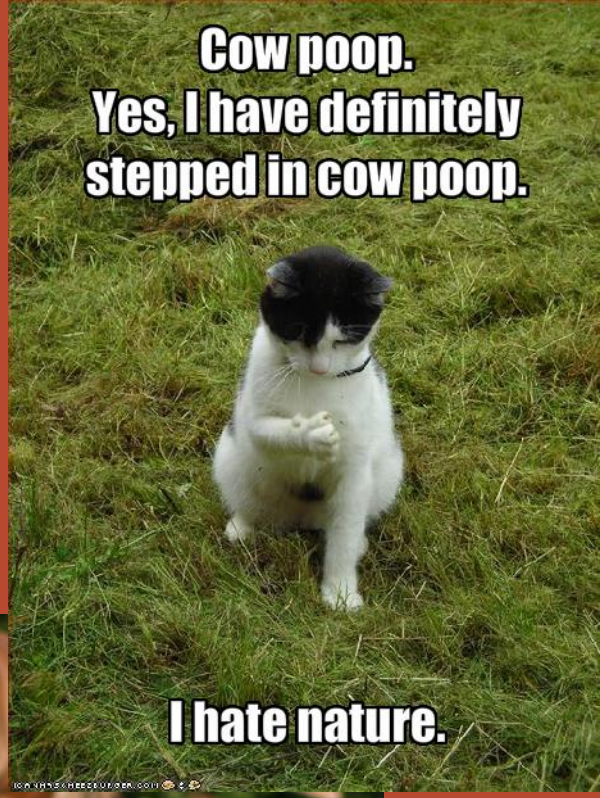
- **Source of the Microorganism**
- Environmental conditions to allow growth or survival
- Sufficient time for growth

Sources of Microorganisms in Spices

- Environment
- Food Itself
- Food Processing Equipment
- Food Handlers

Environmental Sources?

http://www.blogcdn.com/www.greendaily.com/media/2008/03/soil-ammendment-550.jpg



http://en.wikipedia.org/wiki/File:Hestem%C3%B8j.jpg

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Sources of Bacteria in Spices

Sources of Bacteria in Spices

- Equipment

Sources of Bacteria in Foods

- Every employee is a “food handler”
- Hand washing is fundamental to food safety

Major Spice Producing Countries

Country	% of Total Production
India	71.1%
Bangladesh	6.5%
Turkey	6.3%
China	4.6%
Pakistan	2.6%
Ethiopia	1.4%
Everybody Else	7.4%

FAOSTATS, 2012

Unique Microbiology of Spices

- Dry (low moisture, low a_w), Long shelf- life
- Global sourcing, supply chain
- Used in relatively small quantities
- Processing, re processing and packaging
- May be used singly or, as a part of mixture, condiments
- Bacteriostatic and antimicrobial properties
- Microbiologically stable

Microbiology of Spices

- Raw spices may harbor large numbers of organisms
- Total plate counts/spoilage organisms - ~10^6
- Aerobic and anaerobic spore formers – mostly mesophilic
- Yeats and molds, some mycotoxigenic
- Potentially pathogenic organisms, especially Salmonella
- Indicators/spoilage orgs. – coliforms, Enterobacteriaceae
- Bacillus cereus, Clostridium perfringens

Microbiological Quality of Imported Spices and Herbs

Microbial group/target	No. of Samples	%Samples Meeting target
Total $<10^6$/g	113	73
Spores $<10^6$/g	114	75
Yeast and molds < $1o^5$/g	113	97
TA Spores < 10^3/g	114	70
+ for E. coli, S. aureus, Salmonellae	114	0

[1] Julseth, R. M., and R. H. Deibel. 1974. Micorbial profile of selected spices and herbs at import. J. Milk Food Technol. 37: 414-419.

Microbiological Quality of Processed Spices

Microbial group/target	No. of Samples	%Samples Meeting target
Total $<10^5$/g (10^6/g)	114(114)	70 (91)
Coliforms $<10^2$/g	114	97
Yeast and molds < 1o^4/g	113	96
C. perfringens $<10^2$/g	114	89
+ for B. cereus	110	53

[1] Powers, E.M., R. Lawyer and Y. Masuoka. 1975. Microbiology of processed spices J. Milk Food Technol. 38: 683-687.

Microbiological Examination of Dried Spices and Herbs from Production and Retail Premises in the U.K.

- A study to determine microbiological status of dried spices and herbs in the U.K.
- 96% of 2833 retail samples and 92% of 132 production batches were of satisfactory/acceptable quality.

ACM/913
ADVISORY COMMITTEE ON THE MICROBIOLOGICAL SAFETY OF FOOD INFORMATION PAPER, June 2008

Microbiological Examination of Dried Spices and Herbs from Production and Retail Premises in the U.K.

- *Salmonella* spp. was detected in both dried spices & herbs sampled at retail and production.

- A small proportion of herbs and spices contained high populations of:
  - *B. cereus* (1%, ≥104 cfu/g)
  - *C. perfringens* (0.4%, ≥103 cfu/g)
  - *E. coli* (2.1%,≥102 cfu/g).

- 90% of samples examined recorded as 'ready-to-use'

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Microbial Profile of Raw Spices (count/ g of spice)

	APC	AMS	AnTS	Y&M
Black pepper	$5.5x\ 10^6$ – $5.0\ X\ 10^8$	$5.5x\ 10^6$ – $5.0\ X\ 10^7$	$5.5x\ 10^2$ – $3.0\ X\ 10^5$	**$1.0\ x\ 10^1$- $1.5\ x\ 10^5$**
Oregano	$5.5\ x\ 10^3$ – $1.5\ x\ 10^5$	$1.0\ x\ 10^3$ – $7.5\ x\ 10^4$	$1.0\ x\ 10^1$ – $5.5\ x\ 10^3$	$1.0\ x\ 10^1$- $5.0\ x\ 10^3$
Paprika (domestic)	$3.0x10^4$ to $5.5x10^6$	$5.5x10^3$ to $5.5x10^6$	$1.0x10^1$ to $5.5x10^3$	**$1.0x10^1$ to $5.0x10^2$**
Paprika (imported)	$5.5x10^6$ to $3.0x10^7$	$5.5x10^6$ to $3.0x10^7$	$1.0x10^1$ to $3.0x10^4$	**$1.0x10^1$ to $5.0x10^2$**
Nutmeg	$1.0x10^3$ to $3.0x10^4$	$1.0x10^3$ to $5.5x10^3$	$1.0x10^1$ to $5.5x10^3$	**$1.0x10^1$ to $5.0x10^2$**

Source: ASTA- Microbial Profile of Raw Spices

Microbial Profile of Raw Spices (count/ g of spice)

	APC	AMS	AnTS	Y&M
Black pepper	$5.5x\ 10^6$ – $5.0\ X\ 10^8$	$5.5x\ 10^6$ – $5.0\ X\ 10^7$	$5.5x\ 10^2$ – $3.0\ X\ 10^5$	$1.0\ x\ 10^1$- $1.5\ x\ 10^5$
Oregano	$5.5\ x\ 10^3$ – $1.5\ x\ 10^5$	$1.0\ x\ 10^3$ – $7.5\ x\ 10^4$	$1.0\ x\ 10^1$ – $5.5\ x\ 10^3$	$1.0\ x\ 10^1$- $5.0\ x\ 10^3$
Paprika (domestic)	$3.0x10^4$ - $5.5x10^6$	$5.5x10^3$ - $5.5x10^6$	$1.0x10^1$ - $5.5x10^3$	$1.0x10^1$ - $5.0x10^2$
Paprika (imported)	$5.5x10^6$ - $3.0x10^7$	$5.5x10^6$ - $3.0x10^7$	$1.0x10^1$ to $3.0x10^4$	$1.0x10^1$ - $5.0x10^2$
Nutmeg	$1.0x10^3$ - $3.0x10^4$	$1.0x10^3$ - $5.5x10^3$	$1.0x10^1$ to $5.5x10^3$	$1.0x10^1$ - $5.0x10^2$
Mustard seed	$1.0x10^3$ - $7.5x10^5$	$1.0x10^3$ - $3.0x10^4$	$1.0x10^1$ to $5.0x10^2$	0 - 9
Ginger	$5.5x10^3$ - $5.5x10^6$	$5.5x10^3$ - $5.5x10^6$	$1.0x10^1$ to $5.5x10^3$	$1.0x10^1$ - $3.0x10^4$

Source: ASTA- Microbial Profile of Raw Spices

Spice Recalls due to Salmonella

Year	Product	Pathogen
2001	Paprika	*Salmonella ohio*
2002	Oregano	*Salmonella bispebjerg*
2002	Sesame seeds	*Slamonella senftenberg*
2003	Basil leaves	*Salmonella haifa*
2003	Ground cumin	*Salmonella onderstepoort*
2004	paprika	*Salmonella spp.*
2004	Powdered red pepper	*Salmonella darby*
2007	Veggie booty[1] (seasoning)	*Salmonella wadsworth* *Salmonella typhimurium*
2010	Red and Black pepper	*Salmonella montevedio*

Food Borne Disease?

FDA's Draft Risk Profile

Spices have been associated with very few foodborne disease outbreaks and recalls

a. 3 outbreaks associated with spices between 1973 and 2010
b. CDC reported 13,405 outbreaks between 1998 and 2008
c. Spices would account for only 0.02% of the outbreaks

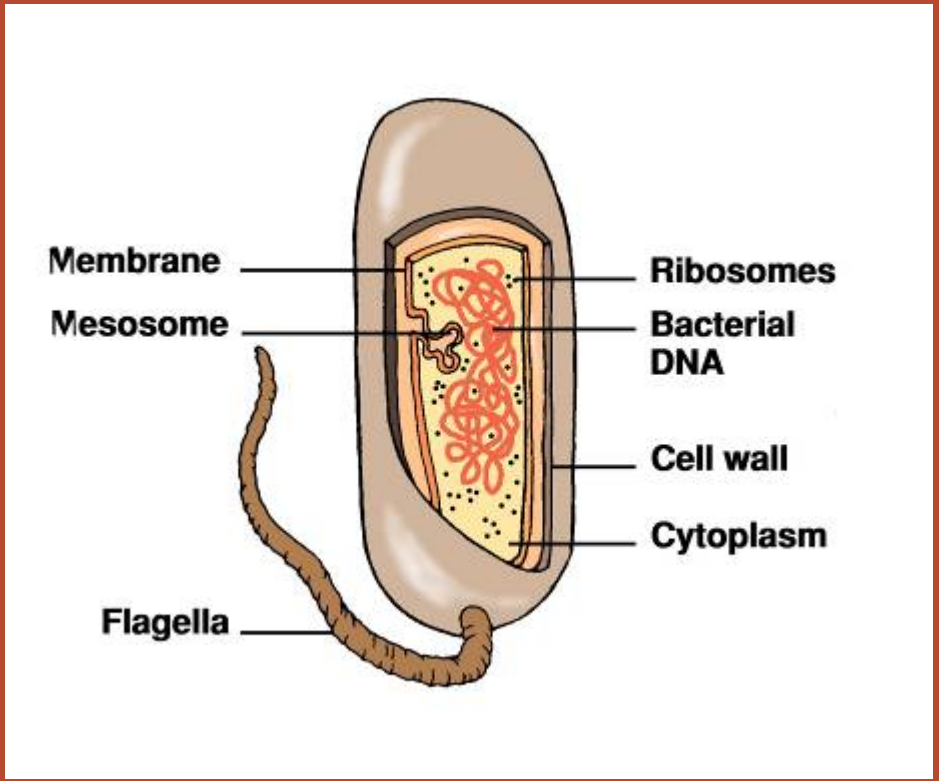
FDA's Draft Risk Profile

The majority of the data represents spices before any mitigation treatments have been applied

a. FDA sampled at the port of entry, or shortly thereafter
b. Most spices are subjected to microbial reduction treatments, or used in multi-component foods which undergo treatment
c. FDA sampled 2844 individual lots of spices, 187 of which were positive

Bacteria

- Largest group of microorganisms
- Most important group from a food microbiology perspective



Bacteria

- Single cells
- Average size
  - 25,000 side by side = 1 inch
  - 1 cubic inch contains about 9 trillion cells

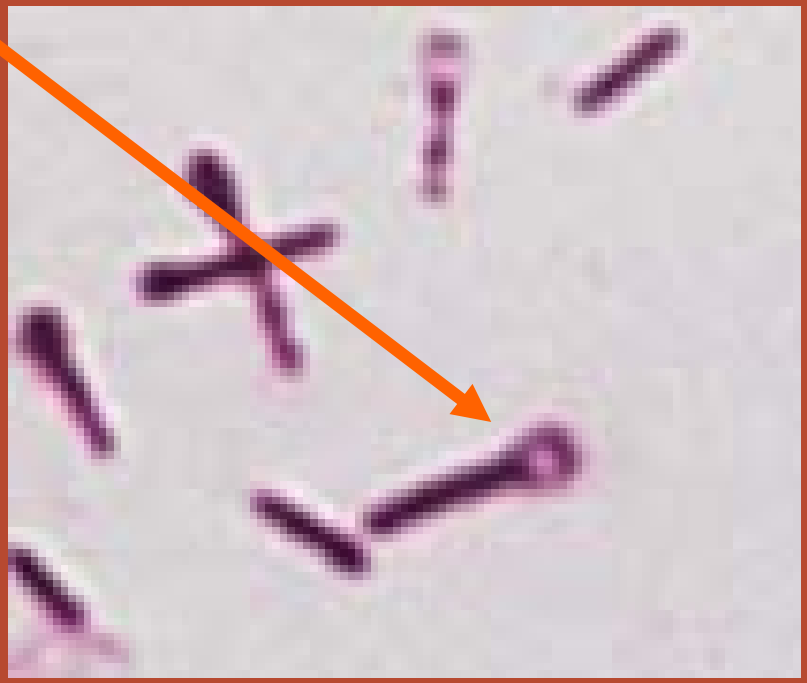
Endospores

- Vegetative cells -
  cells that are engaged in growth, metabolism and reproduction

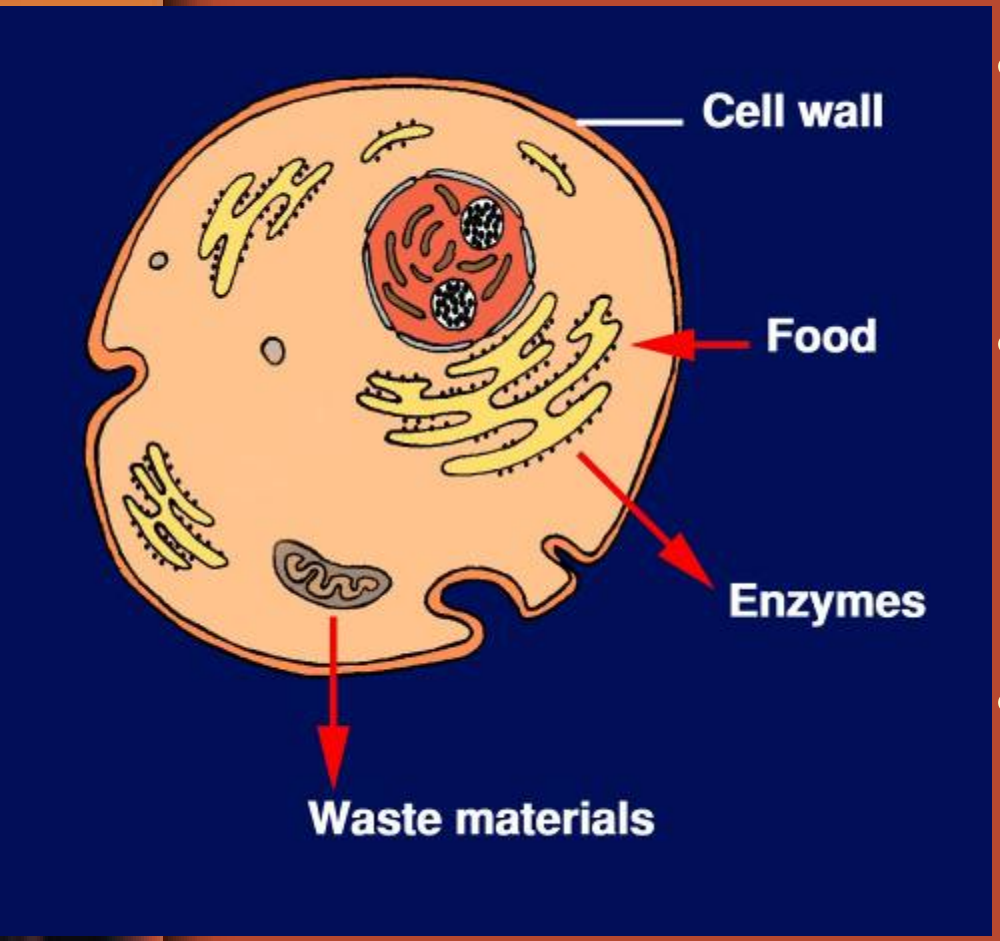
- Endospores -
  a resistant resting body formed in response to environmental stress

Endospores

- Formed by only a few bacterial general
- (*Bacillus* and *Clostridium*)
- spores are very resistant to environmental stress
  - Heat
  - Radiation
  - drying



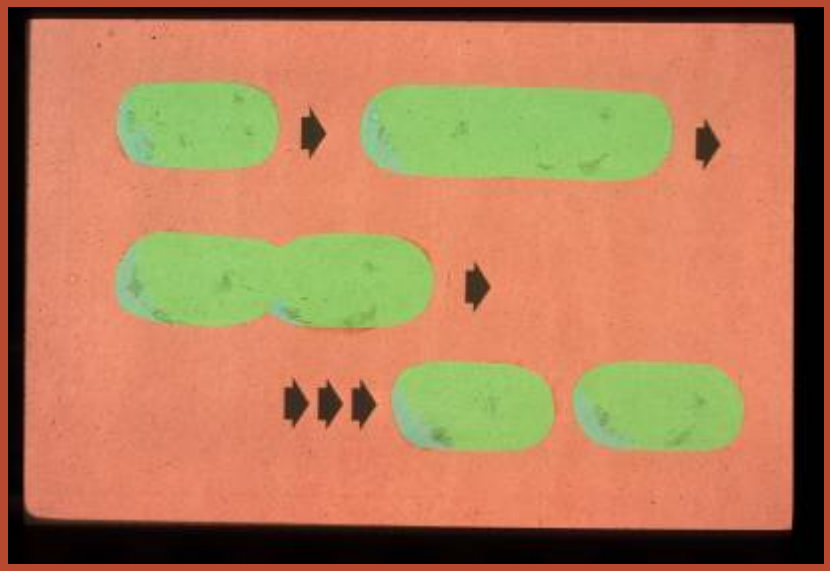
Bacterial Anatomy



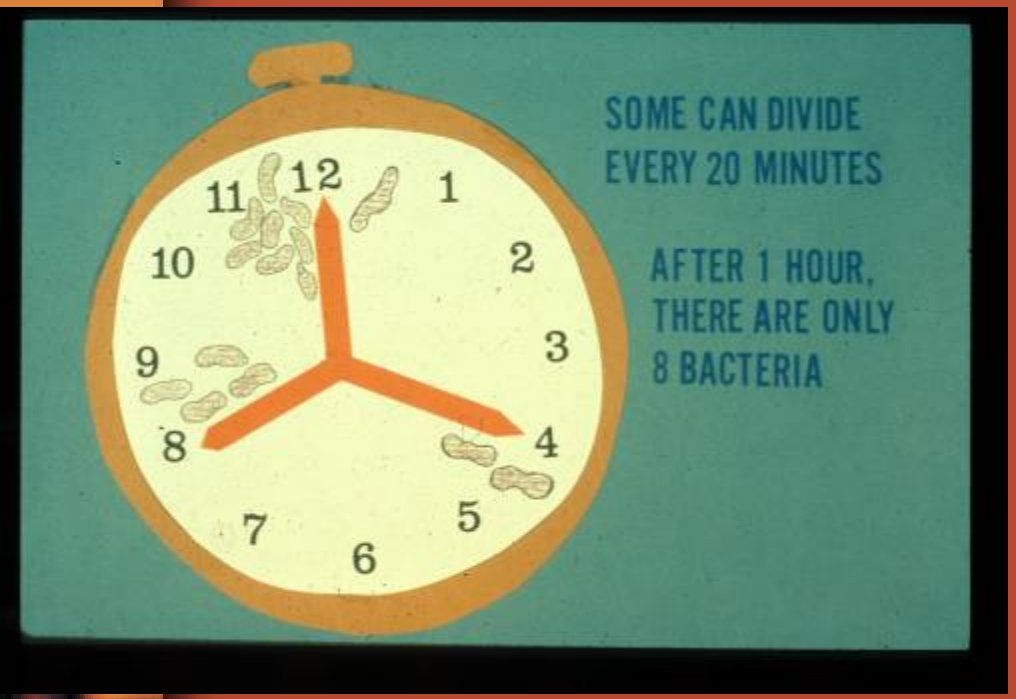
- Self contained, single cell
- Absorbs nutrients from the environment (food)
- Excretes waste products into the environment (food)

Bacterial Reproduction

- Bacteria reproduce by binary fission
- Cell elongates, genetic material duplicates, divides into two cells



Growth



- Some bacteria, under the right conditions, can divide every 20 minutes
- Bacterial numbers increase by doubling
  1cell = time 0
  2 cells = 20 min
  4 cells = 40 min
  8 cells = 60 min

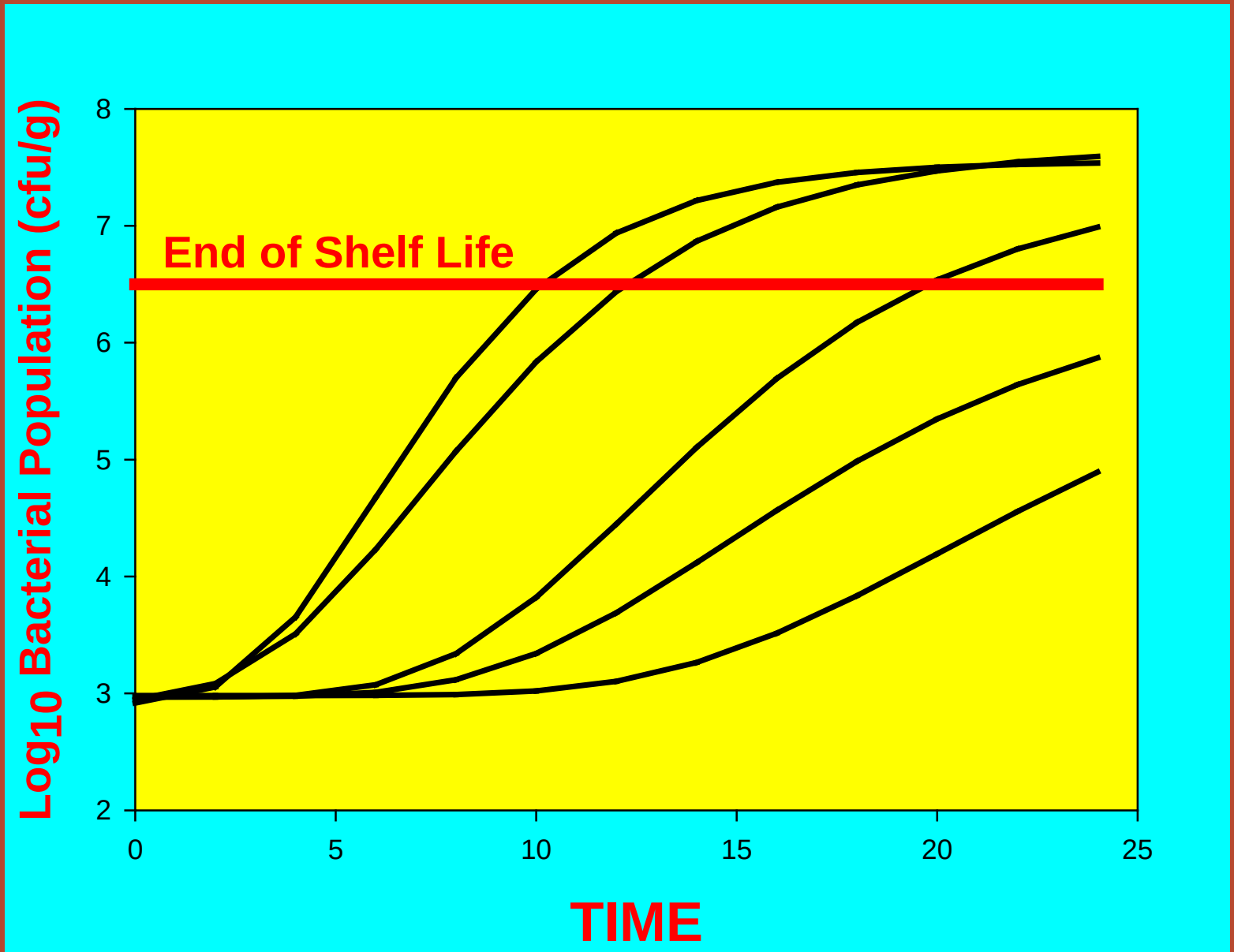
Bacterial Growth

- Bacterial numbers increase by doubling
- At this rate, 1 cell can become 16 million cells after 8 hours under the right conditions

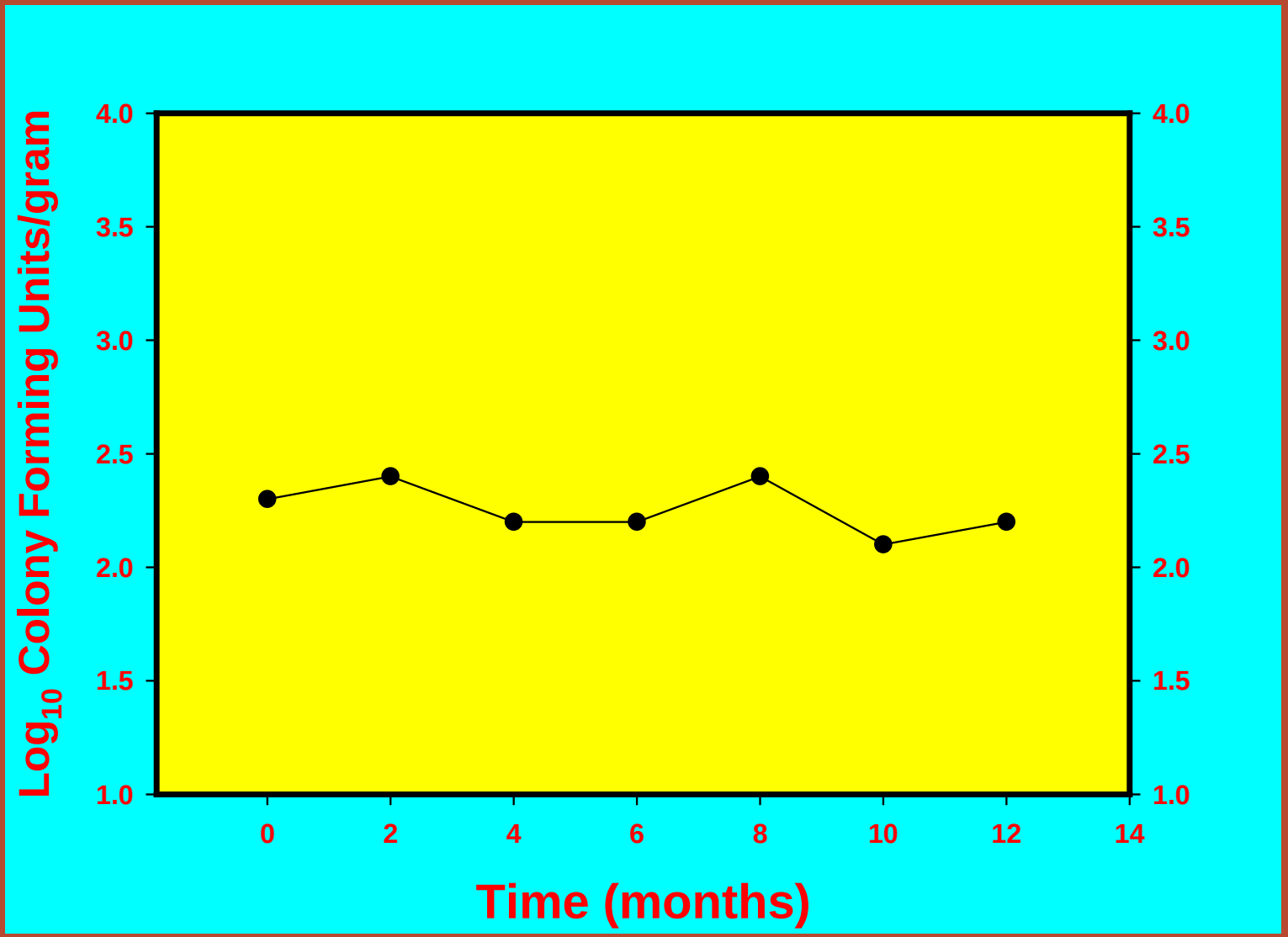
Bacterial Growth

1 – 2 – 4 – 8 – 16 – 32 – 64 – 128 – 256 - 512 – 1024 – 2048 – 4096 – 8192 – 16,384 – 32,768 – 65,536 – 131,072 – 262,144 – 524,288 – 1,048,576 - 2,097,152 – 4,194,304 – 8,388,608 – 16,777,216

Impact of Microbial Growth on Shelf Life



Bacterial Survival in Spices (low moisture)



Upcoming Webinars

- Webinar II
  - Microbiology of Spices, Part 2
- Webinar III
  - Interventions to control microorganisms in spices
- Webinar IV
  - Sampling and analysis