Clostridium botulinum and Reduced Oxygen Packaged Refrigerated Foods

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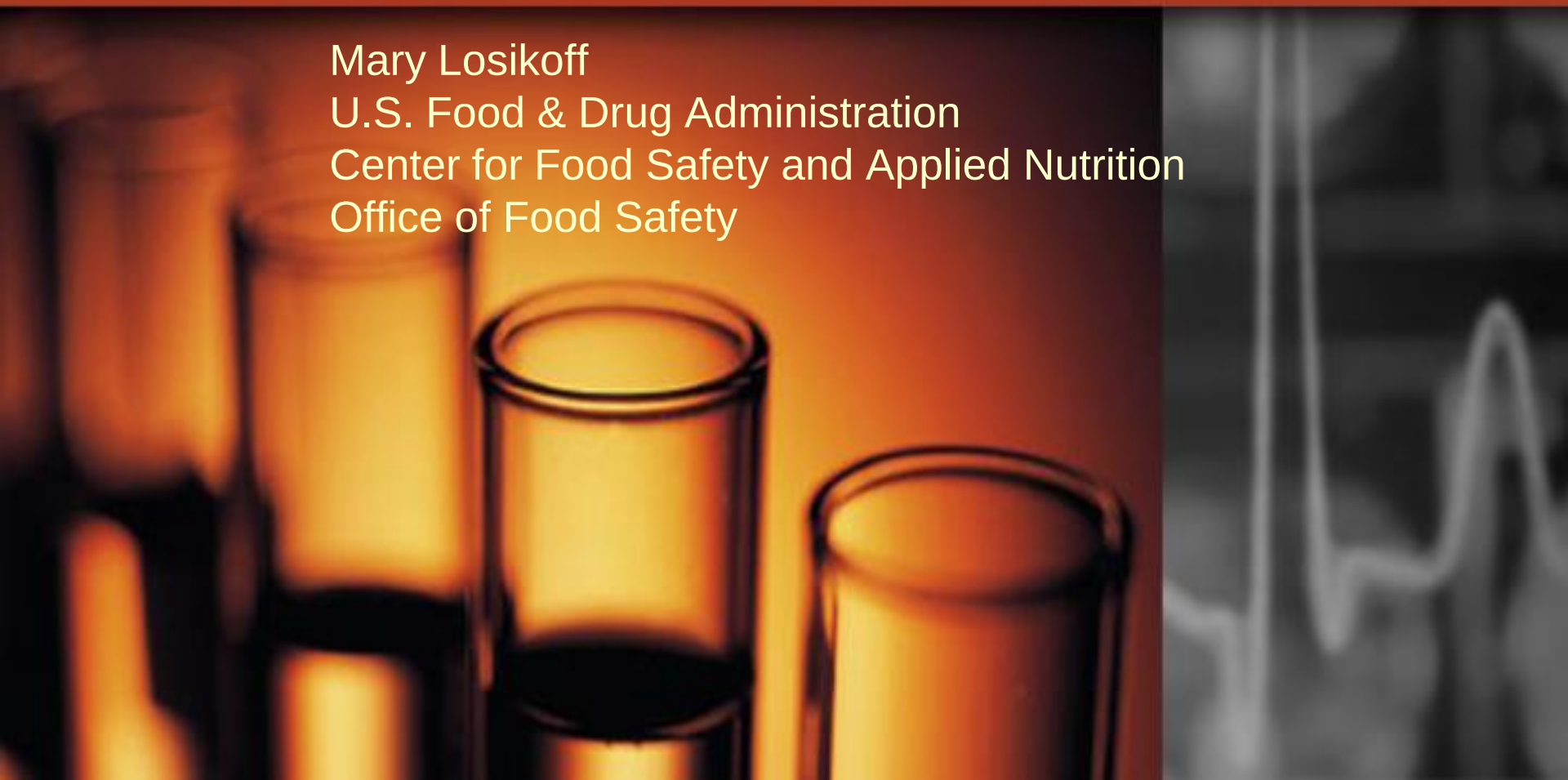
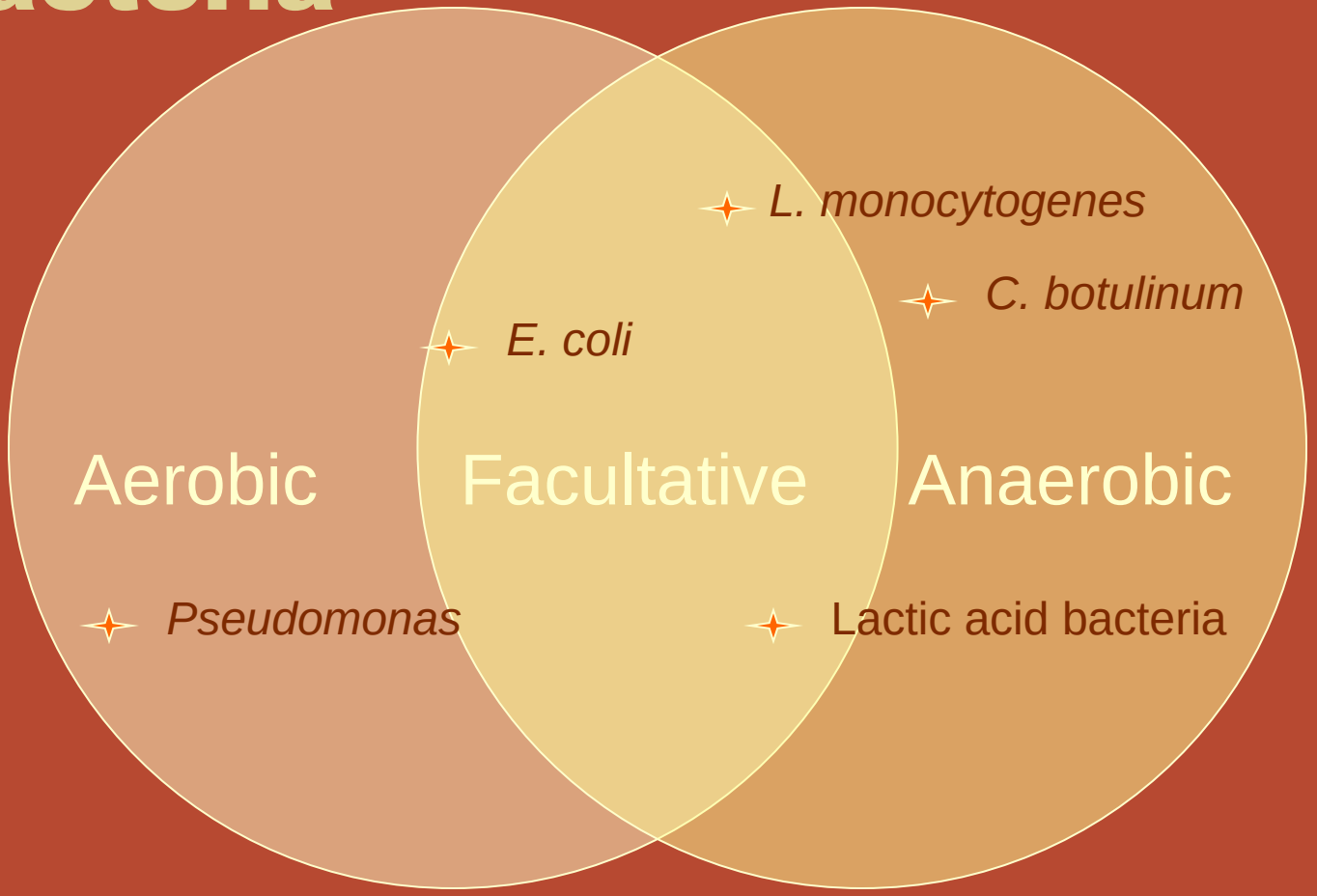


Oxygen Requirements of Bacteria



Oxygen Dependent

Oxygen Intolerant

Reduced Oxygen Packaging

- Vacuum packaging
- Modified atmosphere packaging
- Hermetically sealed containers
  - double seam can
  - glass jar with lid

Factors Affecting Oxygen Availability in Foods

- Packaging – high barrier materials like foil, metal, glass and some polymers prevent or slow the diffusion of oxygen into the food
- Bacterial growth – aerobic bacteria can grow on a food and consume the available oxygen

Factors Affecting Oxygen Availability in Foods

- Heat processing – heat drives air (and thus oxygen) out of foods
- Rate of diffusion – solid foods may not allow oxygen to diffuse as rapidly as liquid foods
- Protein content – sulfhydryl groups in the amino acids methionine and cysteine scavenge oxygen

OTR of Packaging

- Oxygen Transmission Rate (in the final package)
- 10,000 cc/ m2/24 hours at 24ºC considered oxygen-permeable packaging material for **fishery** products
- OTR listed in packaging specifications from the packaging manufacturer

Goal of OTR

- An oxygen-permeable package should provide sufficient exchange of oxygen to allow aerobic spoilage organisms to grow and spoil the product before toxin is produced under moderate abuse temperatures.

Determine the safety of a packaging material

Not always appropriate - examples

- Spoilage organisms eliminated or significantly reduced
  - high pressure processing or product heated in the package
- Products packed in oil
- Deep containers from which the air is expressed
- Use of oxygen scavengers in the packaging
- Products with high respiration rate – vegetables
- Raw products – respiration can use up oxygen
- Cooked products - drive off oxygen

Points to Remember

- Think on a bacteria or molecular level – how is oxygen interacting with the food and the package
- Don’t give packaging more credit than it deserves – food can be anaerobic WITHOUT a package

Clostridium botulinum

- Produces the most potent neurotoxin known, particularly when taken orally (7 – 70 µg for a typical person)
- Classified by toxin type: A, B, C, D, E, F, G – types C and D do not affect man
- Most human illness is caused by types A, B and E and occasionally F

- Spore-forming bacteria (anaerobic)
- Vegetative cells - susceptible to heat
- Spores - heat resistant, survive adverse conditions
- Toxin - not resistant to heat
- Low incidence of disease
- High mortality if not treated

Botulism

- Onset 12 to 36 hours (2hrs – 14 days)
- Early weakness and vertigo – progressive paralysis
- Causes bilateral, descending weakening and paralysis of skeletal muscles
- Double vision - difficulty in speaking – swallowing – breathing
- Abdominal distention, symptoms may also include vomiting, diarrhea or constipation
- Respiration is inhibited and death from asphyxia
- Early administration of botulinal antitoxin/mechanical ventilation

Clostridium botulinum

- Widely distributed in nature

  - found throughout the world in soil, marine and freshwater environments

  - sediments of streams, lakes, and coastal waters
- Spores are common in root vegetables, many spices, the intestinal tracts of fish and mammals, and the gills and viscera of crabs and other shellfish

Clostridium botulinum

- Proteolytic (A,B,F) - degrade protein - visual signs of growth - limit for growth is 10C (50F)
- Non-proteolytic (B,E,F) – do not degrade protein - product may be toxic without signs of growth - limit for growth is 3.3C (38F)
- Type E – non-proteolytic, primarily associated with seafood products
- Botulinum toxin is destroyed by boiling, but is resistant to acid and freezing

Control *Clostridium botulinum nonproteolytic, proteolytic*

- Apply chemical inhibitors
  - Salt 5.0% wps, 10% wps
  - pH 5.0, pH 4.6
  - Water activity below 0.97, 0.93
- In combination with refrigeration at 4.4C（40F）

Recent Botulism Outbreaks

- Most cases of botulism are due to home-prepared foods
- Recent botulism outbreaks due to commercial foods are the result of extreme temperature abuse

  - refrigerated foods stored at room temperature (products appear shelf stable)
- Outbreaks due to commercially processed low acid canned foods are rare

1990 to 2000 United States

- 160 foodborne botulism events
- 263 people affected
- an annual incidence of 0.1 per million
- highest incidence Alaska, Idaho, and Washington
- 131 cases (50%) type A,
- 27 (10%) type B
- 97 (37%) type E

Not home made (1990-2000)

Commercial

Salted,uneviscerated fish (mohola) 3

- Palani (surgeon fish) 3
- Burrito 1
- Clam chowder 2
- Bean dip 1

Restaurant-made

- Cheese sauce 8
- Skordalia potato dip 17

Botulism Outbreaks proteolytic

- Refrigerated pasta sauce in a plastic pouch in a cardboard carton
- Refrigerated bean dip in a 16 oz plastic tub with a snap fit lid
- Refrigerated garlic in oil
- Refrigerated carrot juice in a plastic bottle
- Sautéed onions left in a warm skillet overnight
- Baked potato wrapped in foil

Botulism Outbreaks nonproteolytic

- Kapchunka – uneviscerated fish– New York/Israel, 1987 - 8 cases
- Beached whale – Western AK, 2002 8 cases
- Fermented salmon roe – Canada, 2001 – 4 cases
- Frozen vacuum packed scallops – France, 1998 – 1 case
- Frozen vacuum packed prawns – France, 1998 – 1 case

Control of *C. botulinum* in Unique Foods

- Shelf-stable pasteurized process cheese – must file a process with FDA that uses moisture, pH and phosphate interactively to prevent growth
- Fresh mushrooms – must have 2 (two) ¼ inch holes in package film
- Garlic in oil must be acidified
- Low acid juices must have an effective barrier to growth of proteolytic and non-proteolytic *C. botulinum*

Refrigerated, ROP, pasteurized

- Heat - 10 minutes at 194F (90C) target nonproteolytic *C. botulinum*

  - (1) pasteurized in the final container

  - (2) cooked in a kettle and then hot filled into the final container in a continuous, closed filling system (e.g., heat-and-fill soups, chowders, and sauces)

Refrigerated, ROP, pasteurized seafood

Chemical inhibition nonproteolytic *C. botulinum*

- Water phase salt 5%
- pH of 5
- Water activity below 0.97
- Combination (hurdles)

Plus

- *Listeria* cook in package - 2 minutes 158F

OR

- Freeze the product

Refrigerated or Frozen ROP - seafood

- Raw – refrigeration is sole barrier
- Below 38F
- TTI

- Frozen – freezing is sole barrier – each package labeled to be kept frozen (e.g., Keep frozen, thaw under refrigeration immediately before use)