CONTAMINATION, SPOILAGE, CONTAMINATION AND PRESERVATION OF FOOD (CONTINUED)

Sources of Contamination

- **Pre-harvest Contamination**
- **Post- harvest contamination**

- Microbiological contaminants are found everywhere in or on plants, animals, soil, and water.

- Bacteria such as pseudomonads, lactics, micrococci, and coliforms, grow easily readily on agricultural and horticultural plants.

- Bacteria that have their habitat on both plants and animals can be carried along with the raw materials during harvest, slaughter, and processing.
- Such organisms remain in the food products derived from these sources
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- Soil contains diverse community of microorganisms – bacteria, yeasts, molds, actinomycetes, etc. Indirect contamination with soil occurs through the deposition of wind-borne dust particles.

- Wind-borne mold spores, for example, are a very common cause of mold spoilage of foods

- Water can serve as a source and a vector of contamination.

e.g. Pseudomonads, in in surface waters; enteric bacteria in sewage and waters polluted with sewage.

- Water can serve as a vector of contamination: polluted surface waters may be sprayed onto crops for irrigation or used in primary produce processing.

Postharvest Contamination

- Foods have a structural integrity that protects most of their mass from microbial contamination.
- Animal flesh is also are considered to be sterile.
- Trimming, chopping, or crushing of fruits and vegetables will similarly contaminate the interior portions with those microorganisms existing on the exterior.

- Feces of animals contain >10^{11} cells/g . If the gastrointestinal tract is not carefully removed during slaughter, very high contamination of the muscle tissue could occur.

- In the case of meat production, the first slaughter operations contaminate the surface of the exposed muscles to some extent.

- During further processing contamination can occur when workers handle the food, unclean hands or gloves and uniforms.
- Human contamination of foods can also occur when talking, coughing, or sneezing creates aerosols.
- Cross-contamination with raw materials and by contact with unclean food-handling utensils and processing equipment

Groups of Microorganisms Involved in Spoilage

1. Molds*:*

- water activity from 0.62 to nearly 1.0.
- broad range of temperatures
- Obligate aerobes

2. Fermentative yeasts:

- Also called “spoilage yeasts”
- Facultatively anaerobic
- fermentative organisms, producing ethanol and carbon dioxide from simple sugars.

- They are the most osmophilic organisms
- capable of slow growth at water activity 0.60
- Representative genera include *Saccharomyces* and *Zygosaccharomyces.*

3. Oxidative yeasts:

- less common in spoilage
- aerobic
- Also called “film yeasts”
- can grow on fermented foods

- Representative genera include *Mycoderma, Candida, Pichia,* and *Debaryomyces.*

4. Pseudomonadaceae.

- principal genera *Pseudomonas* and *Xanthomonas*
- Gram-negative rods,
- nonspore forming,
- psychrophilic,

- Aerobic
- intolerant of reduced water activity (above 0.98).
- Addition of small amounts of solutes, such as 2% sodium chloride, will substantially restrict their growth.
- Pseudomonads are primary spoilage microorganisms in fresh meat, poultry, seafood, and eggs.

5. Neisseriaceae.

- Gram negative rods
- nonspore forming,
- aerobic, and catalase positive
- spoilage genera are *Acinetobacter* and *Moraxella*
- Some strains of *Acinetobacter* are psychrophilic.

6. Enterobacteriaceae.

- Gram-negative rods
- facultatively anaerobic,
- fermentative
- Mesophilic
- nonspore forming,
- Catalase positive
- incapable of growth below water activity 0.95.

- 28 genera in this family are commonly called “enteric” bacteria and ferment glucose with the production of acid and gas.
- A subset of this family, containing about half of the genera, is commonly called “coliform” bacteria, as established by their ability to ferment lactose with the production of acid and gas.

- Representative spoilage genera include *Escherichia, Erwinia, Enterobacter, Citrobacter, Serratia*, and *Proteus.*
- Enteric bacteria are often involved in the spoilage of fresh vegetables, meat, poultry, fish, and eggs.

7. Micrococcaceae.

- principal genera – *Micrococcus* and *Staphylococcus*.
- Gram positive,
- Spherical
- catalase positive,
- and mesophilic.

- *Micrococcus* is oxidative, growing on glucose without the production of acid or gas.
- *Staphylococcus* is fermentative, producing both acid and gas from glucose. *Staphylococcus* is osmotolerant.
- Both genera are commonly involved in the spoilage of fresh produce and processed meat, poultry, and seafood.

8. Lactic Acid Bacteria

- Gram positive,
- Catalase negative,
- microaerophilic or facultatively anaerobic,
- and fermentative.
- Homofermentative
- Heterofermentative

- *Lactobacillus* is rod shaped
- *Streptococcus, Lactococcus, Leuconostoc, Enterococcus*, and *Pediococcus* are spherical.
- water activity values above 0.9.
- The growth of lactics in meat, vegetable, and dairy products is used to advantage to produce fermented foods such as sauerkraut, and cheese.

- but growth meats, vegetable salads, and fluid milk, constitutes spoilage.

9. Coryneforms

- sometimes involved in cheese spoilage.
- representative genera are *Corynebacterium* (facultatively anaerobic) and *Brevibacterium* (aerobic).
- both are Gram positive and catalase positive

10. *Spore-forming Bacilli.*

- three major genera are important in food spoilage – *Bacillus, Clostridium*, and *Alicyclobacillus*.
- Gram-positive rods
- generally mesophilic or thermophilic.
- produce heat-resistant endospores
- thus they are the predominant spoilage microorganisms in pasteurized foods in which all vegetative cells have been killed and in improperly sterilized foods.

- *Bacillus* species are:
- aerobic or facultatively anaerobic,
- catalase positive,
- Generally not osmotolerant
- most species are mesophilic, individual species cover
- the entire temperature spectrum for food spoilage

- *E.g. Bacillus cereus* can spoil pasteurized milk (psychrotrophic),
- *B. subtilis* can spoil bakery products (mesophilic), and
- *B. stearothermophilus* can spoil canned foods (thermophilic).

Clostridium species are:

- obligate anaerobes
- catalase negative
- not osmotolerant.
- involved in the spoilage of foods that have a highly negative O/R potential, such as canned or vacuum-packaged foods.
- principal spoilage species are *C. sporogenes* and *C. butyricum* (mesophilic) and *C. thermosaccharolyticum*
- (thermophilic)

Alicyclobacillus:

- First isolated from acid hot springs
- alicyclobacilli are extreme acidophiles,
- pH range of about 2.0–6.0.
- moderate-to-obligate thermophiles
- catalase positive, and
- microaerophilic.
- like pseudomonads, the alicyclobacilli cannot tolerate osmotically increased environments,
- Minimum water activity of 0.98

- principal spoilage species is *A. acidoterrestris*
- spoilage of pasteurized fruit or vegetable

juices that have been improperly cooled or stored at relatively high temperatures, above 30◦C.

SPOILAGE OF SELECTED SOME FOODS

- The driving forces that guide the selection of predominant spoilage microorganisms are “intrinsic” and “extrinsic” factors already discussed.

FRESH RED MEATS

- Meats are the most perishable of all major foods.

- With an abundance of all nutrients required for the growth of bacteria, yeasts, and molds, and an adequate quantity of these constituents exists in fresh meats in available form.

- E.g. water 75.5%, Protein 18.0 %, Fat 3.0 %, Amino acids 0.35 %, Glucose-6-phosphate 0.17 %, Glycogen 0.10 %, Glucose 0.01 %, phosphorus 0.20 %, Potassium 0.35 %, Sodium 0.05 %, Magnesium 0.02 %, Calcium 0.007 %, Zinc 0.005 %.

Bacteria

Genera mostly reported in the spoilage of fresh meat are *Acinetobacter, Aeromonas, Enterococcus, Moraxella, Pseudomonas* and *Psychrobacter*.

Those frequently reported in the spoilage of poultry are *Acinetobacter, Campylobacter, Corynebacterium, Listeria, Micrococcus, Pseudomonas* and *Vagococcus.*

- Intrinsic parameters: pH, nutrient content, moisture and oxidation – reduction (O/R) potential, antimicrobial constituents.

- Extrinsic parameters: temperature of storage, relative humidity of environment, presence and concentration of gases, presence and activities of other microorganisms.

- The first i. e. temperature of storage stands out as being of utmost importance in controlling the types of microorganisms that develop on meats.

- Meat and meat products are normally held at refrigerator temperatures.

- Most studies on the spoilage of meats, poultry, and seafood have dealt with low-temperature-stored products.

- “Bone taint” or “sours”: when beef undergo deep spoilage, usually near the bone. *Clostridium* and *Enterococcus* are the primary causative agents.

- Freshly cut meats stored in a refrigerator with high humidity invariably undergo bacterial spoilage preferential to mold spoilage.

- Surface sliminess. *Pseudomonas* spp.

- Molds tend to predominate in the spoilage of beef cuts when the surface is too dry for bacterial growth or when beef has been treated with antibiotics.

Fungi

- Fungi are of considerably less importance in poultry spoilage (except when antibiotics are employed).
- Fresh meat: *Cladosporium, Mucor, Rhizopus, Sporotrichum,* and *Thamnidium.*

- *“*Whiskers” in beef: *Thamnidium*, *Mucor*, and *Rhizopus*
- “Black spot”: *Cladosporium*
- Green patches : *Penicillium*
- “White spot”: *Sporotrichum* and *Chrysosporium*

- Molds generally do not grow on meats if the storage temperature is below 5◦C.
- Poultry: None.

Yeast

Fresh meat: *Candida* and *Torylopsis*

Poultry: *Candida, Debaryomyces, Rhodotorula* and *Yarrowia.*

- It is well established that the spoilage of meats at low temperature is accompanied by the production of off-color compounds such as ammonia, H_2S, indole, and amines.

- Meat that is clearly spoiled from the standpoint of organoleptic characteristics (odor, touch, appearance, and taste) is, indeed, spoiled.

- Diamines, cadaverine, and putrescine are metabolic byproducts of meat spoilage have been studied as spoilage indicators of meats.