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
• .
• 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 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 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.
- 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

- 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 *Torylopusis*

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$_2$S, 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.