

Microbial spoilage of food groups

1. Introduction

Microbial food spoilage results from the growth and metabolic activity of microorganisms (bacteria, yeasts, molds) that degrade food components, leading to sensory changes (taste, odor, texture, appearance) and loss of quality, without necessarily posing an immediate toxic risk (unlike foodborne illnesses).

2. General spoilage mechanisms

- Enzymatic hydrolysis of macromolecules (proteins, lipids, carbohydrates).
- Various fermentations producing acids, gases, alcohols.
- Production of metabolites that are odorous, colored, or viscous.
- Preferential degradation of certain nutrients.

3. Spoilage by food group

A. Meat products (red meat, poultry, processed meats)

Predominant bacteria: *Pseudomonas*, *Brochothrix thermosphacta*, *Lactobacillus*, *Enterobacteriaceae*.

Typical spoilage signs:

- Surface slime: Exopolymers produced by *Pseudomonas* and *Lactobacillus*.
- Discoloration: Oxidation of pigments (greening by *Lactobacillus* or *Leuconostoc*; fluorescence by *Pseudomonas*).
- Putrid odors: Protein degradation into amines (putrescine, cadaverine), ammonia, hydrogen sulfide (H₂S) by *Pseudomonas*, *Clostridium*, *Enterobacteriaceae*.
- Sour taste: Lactic acid fermentation by *Lactobacillus* and *Brochothrix*.

B. Seafood (Fish, shellfish)

Specific spoilage organisms: *Shewanella putrefaciens*, *Photobacterium phosphoreum* (marine fish), *Pseudomonas*.

Typical spoilage signs:

- Ammoniacal/putrid odor: Rapid degradation of proteins and trimethylamine oxide (TMAO) into trimethylamine (TMA, rotten fish smell), ammonia, H₂S (*Shewanella*).
- Phosphorescence: Production by *Photobacterium*.
- Tissue softening: Enzymatic hydrolysis of collagen and muscle.

C. Dairy products (milk, cheese, yogurt)

Diverse microflora: Lactic acid bacteria (desirable), but also contaminants: *Pseudomonas*, coliforms, yeasts, molds.

Typical spoilage signs:

Milk:

- Sour curdling: Undesired lactic acid fermentation.
- Bitterness: Proteolysis by *Pseudomonas* or certain lactic strains.
- Rancidity: Lipolysis by *Pseudomonas* or native lipases.
- Gas production (coliforms): Production of CO₂ and H₂ → swelling.

Cheese:

- Undesired surface mold (green, black, blue discoloration).
- Early blowing (butyric fermentation by *Clostridium tyrobutyricum*) or late blowing (excessive propionic fermentation).
- Bitter taste (excessive proteolysis).

Yogurt: Swelling and off-flavors caused by yeasts (*Saccharomyces*) or molds.

D. Fruits and vegetables

Microorganisms: Molds (tissue penetration), yeasts, bacteria (on wounds).

Typical spoilage signs:

- Soft, watery rot: Pectolytic bacteria (*Erwinia carotovora*, *Pseudomonas marginalis*) → tissue maceration.
- Mold rots: *Botrytis cinerea* (gray mold), *Penicillium* (blue/green mold), *Rhizopus stolonifer* (soft, fuzzy rot).
- Alcoholic fermentations: By yeasts on damaged fruit → alcoholic odor, bubbling.

E. Cereals and cereal products (bread, pasta)

Molds: *Aspergillus*, *Penicillium*, *Rhizopus*.

Bacteria: *Bacillus* (in bread).

Typical spoilage signs:

Bread:

- Ropy spoilage: *Bacillus subtilis* (spores survive baking) → sticky, stringy texture, fruity-rotten odor.
- Mold growth: Green spots (*Penicillium*), black spots (*Aspergillus niger*).

Stored grains: Molds producing mycotoxins (spoilage + health hazard).

F. Canned foods (appertized)

Spoilage due to germination of heat-resistant spores.

Types of spoilage:

- Swelling (can bulging):
- Acid + Gas (no H₂S): *Bacillus stearothermophilus* (acidic foods, flat sour).
- H₂S Gas: *Clostridium nigrificans* → rotten egg smell, can appears flat but content blackens.
- Putrefaction + Gas (H₂/CO₂): *Clostridium sporogenes* → swelling and putrid odor.
- Flat sour spoilage (no gas): Acidification, off-flavors by thermophilic *Bacillus* or *Clostridium*.
- Mold spoilage: In low-acid, pasteurized canned foods (jams, fruits) → *Aspergillus*, *Byssoschlamys*.

G. Beverages (juices, soft drinks, wines, beers)

Non-Saccharomyces yeasts, lactic or acetic acid bacteria.

Typical spoilage signs:

- Fruit juices: Alcoholic or acetic fermentation, mold growth.
- Wines: Acetification (acetic acid production by *Acetobacter*), bitterness (certain lactobacilli), mousy taint.
- Beers: Souring (by *Lactobacillus*, *Pediococcus*), cloudiness, ropiness.

H. Fats and oils

Primarily chemical spoilage (oxidative rancidity).

Possible microbial role:

- Hydrolysis of triglycerides (hydrolytic rancidity) by microbial lipases → release of free fatty acids (soapy, sour taste).
- Spoilage organisms in fatty foods (butter, margarine): *Pseudomonas*, *Geotrichum*, *Penicillium*.

4. Factors influencing the type of spoilage

- Food composition: pH, aw (water activity), available nutrients, natural inhibitors.
- Storage conditions: Temperature, atmosphere (O₂/CO₂), humidity.
- Initial microflora (type and load) and applied treatments.
- Packaging integrity.

5. Consequences and prevention

Consequences: Economic loss, food waste, brand reputation damage.

Prevention:

- Temperature control (refrigeration, freezing).
- Reduction of aw (drying, salting, sugaring).
- Atmosphere modification (vacuum packaging, modified atmosphere packaging).
- Hurdle technology (heating, irradiation, biopreservation).
- Strict hygiene and HACCP throughout the supply chain.