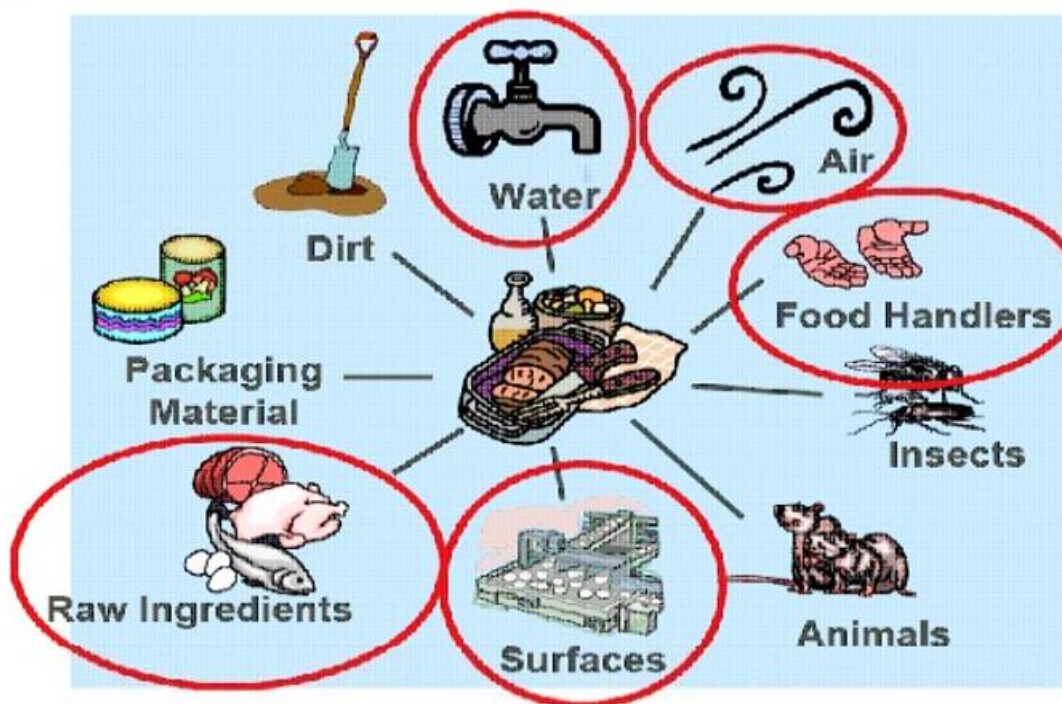


Chapter 3: Sources of microorganisms in foods

3.1. Introduction

- Internal tissues of healthy plants (fruits, vegetables) and animals (meat) are essentially sterile.
- However, raw and processed foods (except sterile) contain molds, yeasts, bacteria, and viruses.
- Microorganisms enter foods from:
 - Natural (internal) sources
 - External sources during production, processing, storage, and consumption
- ✓ **Natural sources:**
 - Plant foods: surfaces of fruits, vegetables, grains; pores in tubers (radish, onion)
 - Animal foods: skin, hair, feathers, gastrointestinal tract, urinogenital tract, respiratory tract, milk ducts (teat canal)
- Natural microflora exist in ecological balance with hosts; types and levels vary with:
 - Type of plant/animal
 - Geographic location
 - Environmental conditions
- ✓ **External sources:** air, soil, sewage, water, feeds, humans, food ingredients, equipment, packages, insects



3.2. Predominant microorganisms in different sources

3.2.1. Plants (fruits and vegetables)

- Internal tissues essentially sterile, except:
 - Porous vegetables (radish, onion)
 - Leafy vegetables (cabbage, Brussels sprouts)
- Some plants produce natural antimicrobial metabolites.
- Surface microorganisms vary with:
 - Soil condition
 - Fertilizer type
 - Water used
 - Air quality
- **Common microorganisms:**
 - Molds, yeasts
 - Lactic acid bacteria
 - *Pseudomonas*, *Alcaligenes*, *Micrococcus*, *Erwinia*, *Bacillus*, *Clostridium*, *Enterobacter*
- **Pathogens** (especially enteric) can be present if soil is contaminated with untreated sewage.
- **Factors increasing microbial numbers:**
 - Plant diseases
 - Surface damage (before, during, after harvest)
 - Delay between harvesting and washing
 - Unfavorable storage/transport conditions
 - Improper storage after processing

3.2.2. Animals, birds, fish, and shellfish

- Normal indigenous microorganisms in:
 - Digestive, respiratory, urinogenital tracts
 - Teat canal in udder
 - Skin, hooves, hair, feathers
- Numbers can be very high (large intestinal contents: up to 10^{10} bacteria/g).
- Asymptomatic carriers may harbor:
 - *Salmonella* serovars
 - Pathogenic *Escherichia coli*
 - *Campylobacter jejuni*
 - *Yersinia enterocolitica*
 - *Listeria monocytogenes*
- Laying birds may carry *Salmonella* Enteritidis in ovaries → contaminate yolk during ovulation.
- Disease situations (mastitis, infections, injury) change normal microflora.

- Poor husbandry (fecal contamination, contaminated water/feed) changes microbial flora.
- **Fish and shellfish:**
 - Normal microflora in scales, skin, digestive tracts
 - Water quality, feeding habits, diseases change microbial types/levels
 - Pathogens of concern: *Vibrio parahaemolyticus*, *Vib. vulnificus*, *Vib. cholerae*
- **Contamination during production/processing:**
 - Milk: fecal materials on udder surface
 - Eggs: fecal material on shells during laying
 - Meat: intestinal contents during slaughtering
 - Fish: intestinal contents during processing
- **Additional contaminants from skin, hair, feathers:**
 - *Staphylococcus aureus*, *Micrococcus* spp., *Propionibacterium* spp., *Corynebacterium* spp., molds, yeasts

3.2.3. Air

- Microorganisms present in dust and moisture droplets.
- Do not grow in dust; transient and variable.
- **Level controlled by:**
 - Humidity
 - Size and level of dust particles
 - Temperature and air velocity
 - Resistance of microorganisms to drying
- Dry air with low dust and higher temperature = low microbial level.
- **Common microorganisms:**
 - Spores of *Bacillus* spp., *Clostridium* spp., molds
 - Gram-positive bacteria: *Micrococcus* spp., *Sarcina* spp.
 - Yeasts
- If surroundings contain pathogen sources (animal/poultry farms, sewage-treatment plant): bacteria, pathogens, viruses (including bacteriophages) can be transmitted via air

3.2.4. Soil

- Contains several varieties of microorganisms.
- Microorganisms can multiply in soil → numbers can be very high (billions/g).
- **Common microorganisms:**
 - Molds, yeasts
 - *Enterobacter*, *Pseudomonas*, *Proteus*, *Micrococcus*, *Enterococcus*, *Bacillus*, *Clostridium*
- **Soil contaminated with fecal materials** → source of enteric pathogenic bacteria and viruses.

- **Sediments** where fish/marine foods are harvested → source of microorganisms, including pathogens.
- **Parasites** can also enter food from soil.

3.2.5. Sewage

- Especially when used as fertilizer in crops → contaminates food with microorganisms.
- **Most significant:** enteropathogenic bacteria and viruses.
- Major concern with:
 - Organically grown food
 - Imported fruits and vegetables (untreated sewage/manure used as fertilizer)
- **Pathogenic parasites** can also enter food from sewage.

3.2.6. Water

- Used to:
 - Produce, process, and store foods
 - Irrigate crops
 - Drink for food animals/birds
 - Raise fishery/marine products
 - Wash foods
 - Process foods (pasteurization, canning, cooling)
 - Store foods (e.g., fish on ice)
 - Wash and sanitize equipment
 - Process and transport facilities
 - As an ingredient in many processed foods
- **Water quality** greatly influences microbial quality of foods.
- **Wastewater** can be recycled for irrigation.
- **Chlorine-treated potable water** should be used in processing, washing, sanitation, and as ingredient.
- **Potable water:**
 - Does not contain coliforms and pathogens (mainly enteric)
 - Can contain spoilage bacteria: *Pseudomonas*, *Alcaligenes*, *Flavobacterium*
- **Improperly treated water** can contain pathogenic and spoilage microorganisms.
- Many food processors use water with higher microbial quality than potable water, especially as ingredient.

3.2.7. Humans

- Foods come in contact with different people:
 - Farms, food processing plants
 - Restaurants, catering services, retail stores, home
- **Human carriers** → source of pathogenic microorganisms in foods → foodborne diseases (especially ready-to-eat foods).
- **Major sources of contamination:**

- Improperly cleaned hands
- Lack of personal hygiene
- Dirty clothes and hair
- Minor cuts and infections on hands/face
- Mild generalized diseases (flu, strep throat, hepatitis A in early stage)
- **Pathogens introduced:**
 - *Staphylococcus aureus*
 - *Salmonella* serovars
 - *Shigella* spp.
 - Pathogenic *Escherichia coli*
 - Hepatitis A

3.2.8. Food ingredients

- In prepared/fabricated foods, many ingredients/additives included in different quantities.
- **Many ingredients can be sources** of spoilage and pathogenic microorganisms.
- **Examples:**
 - Spices: very high populations of mold and bacterial spores
 - Starch, sugar, flour: spores of thermophilic bacteria
 - Dried coconut, egg, chocolate: pathogens isolated

3.2.9. Equipment

- Used in harvesting, slaughtering, transporting, processing, storing foods.
- **Microorganisms from air, raw foods, water, personnel** can get into equipment → contaminate foods.
- Depending on environment (moisture, nutrients, temperature) and time:
 - Microorganisms can multiply
 - Even from low initial population → reach high level → contaminate large volumes of foods
- **Continuous use** → microorganisms multiply → continuous source of contamination.
- **Dead spots** (small parts, inaccessible sections, certain materials) → not efficiently cleaned/sanitized → sources of pathogenic and spoilage microorganisms.
- **Small equipment** (cutting boards, knives, spoons) → improper cleaning → cross-contamination.
- **Microorganisms from equipment:**
 - *Salmonella*, *Listeria*, *Escherichia*, *Enterococcus*, *Micrococcus*, *Pseudomonas*, *Lactobacillus*, *Leuconostoc*, *Clostridium*, *Bacillus* spp., yeasts, molds

3.2.10. Other sources:

Packaging and wrapping materials, containers, flies, vermins, birds, house pets, rodents