UNIT V – TOPIC 3

Role of Technologies

Infrared (IR) Heating

Definition:

Infrared heating is a surface heating method that uses **infrared radiation (0.78–1000 µm wavelength)** to transfer thermal energy directly to food products.

Principle:

- Heat is transferred by **electromagnetic radiation**, not by conduction or convection.
- Food absorbs IR energy, increasing molecular vibration, and thus temperature.
- Efficiency depends on **wavelength**, **emissivity of the surface**, and **absorption** by the product.

Types of Infrared Radiation:

- **Near IR (NIR)**: 0.78–1.4 µm – high energy, deep penetration
- **Mid IR (MIR)**: 1.4–3 µm – moderate penetration
- **Far IR (FIR)**: 3–1000 µm – low energy, surface heating

Advantages:

- **Fast surface heating** – ideal for thin products
- **Energy-efficient** – direct heat transfer
- **Reduced cooking time**
- **Improved texture and flavor** in baked and roasted foods

Applications:

- Baking, roasting, grilling
- Drying of fruits, vegetables, grains
- Surface pasteurization (e.g., nuts, spices)

Limitations:

- Limited penetration depth – only effective for thin layers
- Uneven heating if not properly designed
- Risk of surface scorching

 Irradiation

Definition:

Food irradiation is the process of exposing food to **ionizing radiation** (gamma rays, X-rays, or electron beams) to destroy microorganisms, insects, and parasites and to inhibit sprouting.

Principle:

- Ionizing radiation damages **DNA of microorganisms**, leading to their death or inability to reproduce.
- The process does **not make food radioactive**.
- Doses measured in **Grays (Gy)**.

Types of Radiation Used:

1. **Gamma rays** (from Cobalt-60 or Cesium-137)
2. **Electron beams (e-beam)** – high-speed electrons
3. **X-rays** – generated by machine (deep penetration)

Advantages:

- **Effective sterilization** without heat
- **Extends shelf life**
- **Kills pathogens** like Salmonella, E. coli
- **Reduces postharvest losses** (e.g., in fruits and tubers)
- **Safe and approved** by WHO, FAO, and FDA

Applications:

- **Disinfestation**: Cereals, spices
- **Sprout inhibition**: Potatoes, onions
- **Pathogen reduction**: Meat, poultry, seafood
- **Sterilization**: Medical equipment, packaging

Limitations:

- High initial cost for facility
- Consumer skepticism (labeling as "irradiated" required)
- Slight changes in flavor or texture at high doses

Extra notes :

1. INFRARED HEATING

Basic Principle

- Uses electromagnetic waves (λ = 0.78–1000 µm) to transfer heat
- Energy absorbed → molecular vibration → heat generation
- **Three types**: Near-IR (0.78-1.4 µm), Mid-IR (1.4-3 µm), Far-IR (3-1000 µm)

Mechanism of Action

1. **Surface heating**: Penetrates 0.1–10 mm depending on wavelength
2. **Selective absorption**: Water, proteins, fats absorb specific IR wavelengths
3. **Instant heating**: No medium required (unlike convection/conduction)

Applications

Application	Examples	Benefits
Drying	Fruits, vegetables, grains	Faster than hot-air drying
Baking/Roasting	Bread, coffee, nuts	Uniform browning
Pasteurization	Surface decontamination of foods	Minimal nutrient loss
Peeling	Tomatoes, almonds	Reduces water/chemical usage

Advantages

✓ Energy efficient (up to 80% efficiency)
✓ Rapid heating (seconds to minutes)
✓ Preserves color/flavor better than conventional methods

Limitations

✗ Limited penetration depth
✗ Possible uneven heating in heterogeneous foods
✗ High power requirement for industrial scale

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2. FOOD IRRADIATION

Basic Principle

- Uses ionizing radiation to disrupt microbial DNA
- **Three types**:
    1. **Gamma rays** (from Cobalt-60/Cesium-137) - Deep penetration
    2. **E-beams** (accelerated electrons) - Shallow penetration
    3. **X-rays** - Machine-generated, medium penetration

Mechanism of Action

- Radiation → creates free radicals → damages cellular DNA/RNA
- **Does not** make food radioactive (approved by WHO/FDA)

Applications & Doses

Dose (kGy)	Application	Target Effect
<1	Insect disinfestation	Kills insects in grains/fruits
1-3	Sprout inhibition	Prevents potato/onion sprouting
3-7	Pathogen reduction	Eliminates Salmonella/E. coli
10-50	Sterilization (space foods)	Complete microbial elimination

Advantages

✓ Cold process (minimal heat damage)
✓ Extends shelf life 2-3x
✓ Effective against pathogens/parasites

Limitations

✗ Public perception issues ("radioactive food" myth)
✗ High capital cost for facilities
✗ Can alter flavor in dairy/meats at high doses

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3. KEY COMPARISONS

Parameter	Infrared Heating	Food Irradiation
Energy Type	Non-ionizing radiation	Ionizing radiation
Primary Effect	Thermal	Non-thermal
Depth	Surface (μm–mm)	Bulk (cm-level)
Regulation	Minimal restrictions	Strict dose limits worldwide
Best For	Thermal processing applications	Microbial safety applications

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4. CURRENT RESEARCH TRENDS

Infrared Heating

- Hybrid systems (IR + microwave/hot air)
- Wavelength-specific optimization
- AI-controlled precision heating

Irradiation

- E-beam/X-ray alternatives to gamma
- Combined with MAP (Modified Atmosphere Packaging)
- Consumer education initiatives

5. EXAMPLES IN INDUSTRY

- **IR**: Potato chip pre-drying (PepsiCo), coffee bean roasting (Starbucks)
- **Irradiation**: Spice sterilization (McCormick), imported fruit quarantine (USDA)