

Introduction to Dairy Plant Technology

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Key concepts, main equipment, process flow, and quality considerations

1. Overview of Dairy Plant Technology

- **Definition:** The collection of engineering, microbiological, and food science principles used to transform raw milk into safe, stable, and market-ready dairy products.
- **Objectives:**
 1. Preserve nutritional and sensory quality.
 2. Extend shelf life while ensuring safety.
 3. Optimize resource use (energy, water, labor).
- **Typical Products:** Fluid milk, cream, butter, cheese, yogurt, ice cream, whey protein concentrates, milk powders.

2. Major Process Stages

Stage	Primary Goal	Typical Unit Operations
1. Reception & Pre-Cleaning	Remove gross contaminants; verify milk quality	Sieve, coarse filter, temperature measurement, initial cooling
2. Standardization & Pasteurization	Adjust fat/protein levels; eliminate pathogenic microbes	Separator, homogenizer, heat exchangers (HTST, UHT)
3. Homogenization	Create stable emulsion, improve texture	High-pressure homogenizer (15–25 MPa)
4. Cooling & Storage	Bring product to safe handling temperature	Plate heat exchangers, glycol-cooled tanks
5. Further Processing (product-specific)	Convert base milk into target product	Fermentation tanks, cheese vats, spray-dryers, batch freezers
6. Packaging	Protect product, extend shelf life, provide information	Aseptic filling, flow-pack, bottle/carton lines
7. Cleaning-In-Place (CIP)	Maintain hygiene without disassembly	Alkali/acid cycles, circulating pumps, heat exchangers

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3. Core Equipment & Their Functions

3.1. Reception & Storage

- **Milk Cooler:** Brine or glycol system; reduces milk to 4°C within 2h of milking.
- **Bulk Storage Tanks:** Stainless steel, insulated, equipped with agitators and level sensors.

3.2. Separation & Standardization

- **Centrifugal Separator:** Splits milk into cream and skim; enables fat adjustment.
- **Standardization Mixer:** Recombines streams to achieve target fat (e.g., 3.5% for whole milk).

3.3. Heat Treatment

- **HTST (High Temperature Short Time) Pasteurizer:** 72°C for 15s; typical for fluid milk.
- **UHT (Ultra High Temperature) System:** $135\text{--}150^{\circ}\text{C}$ for 2–4s; creates aseptic products.
- **Plate Heat Exchanger:** Provides rapid heating/cooling with high efficiency.

3.4. Homogenizer

- **Piston or Valve Type:** Forces milk through a narrow gap at high pressure, breaking fat globules to $1\text{--}5\mu\text{m}$.

3.5. Fermentation & Coagulation (Cheese/Yogurt)

- **Stirred Tank Fermenter:** Precise temperature, pH, and agitation control.
- **Coagulation Vat:** Maintains low temperature ($30\text{--}38^{\circ}\text{C}$) for rennet action.

3.6. Drying & Concentration

- **Evaporator (Multiple Effect):** Removes water to produce concentrated milk or whey.
- **Spray Dryer:** Atomizes concentrate into hot air; yields