Dairy and Food Engineering

- Definitions and standards
- Processing steps
- Shelf-life
- Fermented dairy products

Definitions

- Raw milk: The lacteal secretion , practically free from colostrum, obtained by the complete milking of one or more healthy cows (PMO).

- "Consumer Milk" products:
  - Homogenized milk: ≥3.25% fat
  - Reduced fat milk: 2% fat
  - Low fat milk: 1% fat
  - Fat-free milk: skim milk, <0.5% fat

  (all with 8.25% solids-non-fat)

- Other "milk products": lactose reduced milks, heavy cream, cultured milks, yogurt, cottage cheese.

Shelf-life:

Time for which a product can be stored without the quality falling below a certain acceptable minimum level

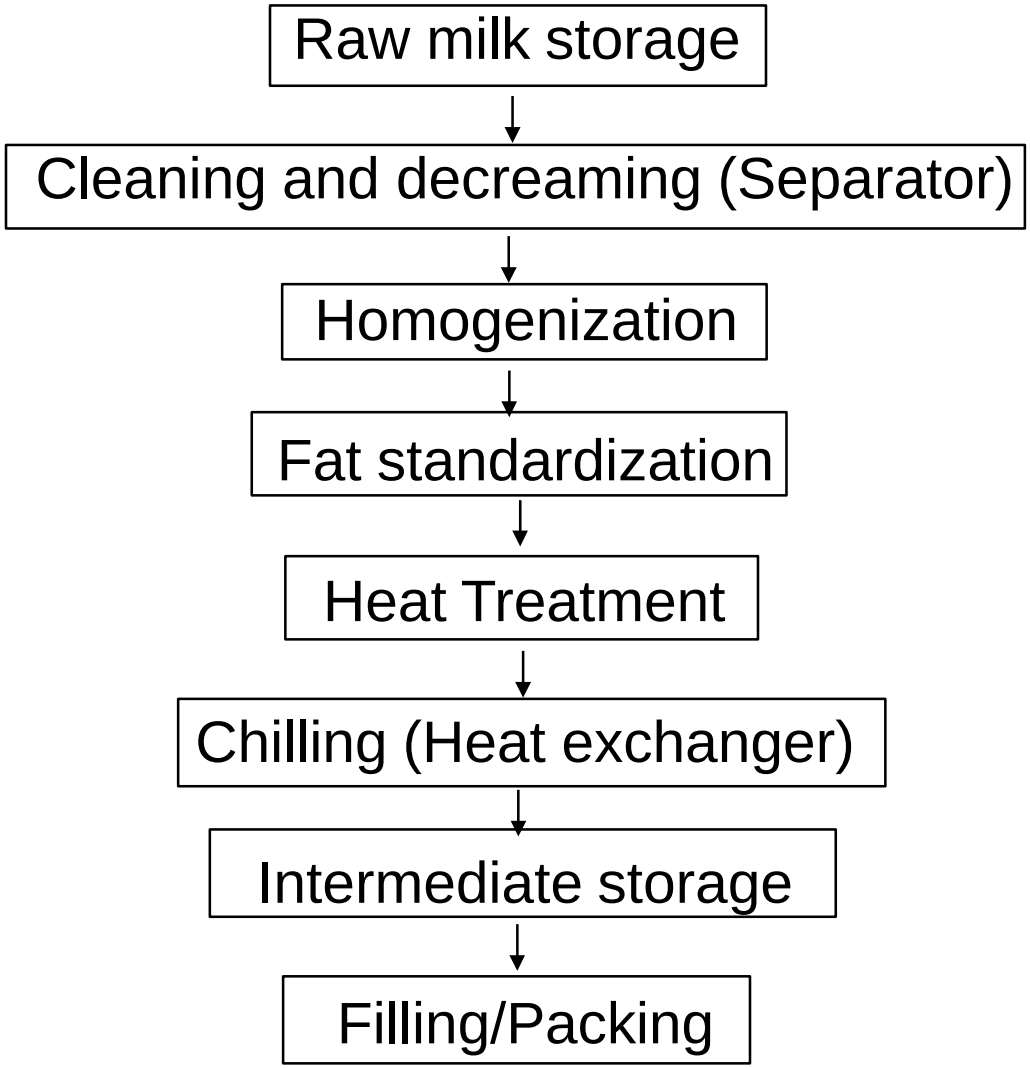
Consumer milk: 14 days, under refrigeration (Muir, 1996)

Pasteurized Milk Ordinance (PMO)

- produced by Public Health Service/Food and Drug Administration
- sanitary regulations for milk and milk products
- specifies sanitation measures throughout production, handling, pasteurization, and distribution of milk

(http://vm.cfsan.fda.gov/~ear/p-nci.htm#pmo96)

Fluid Milk Processing



Raw Milk Quality and Storage

Chemical, bacteriological, and temperature standards for Grade A raw milk for pasteurization, ultrapasteurization or aseptic processing (PMO)

- Temperature: 45ºF or less within 2 h after milking
- Bacterial counts: <100,000 cfu/ml for individual farm milk and <300,000/ml as commingled milk prior to pasteurization
- Somatic Cell Counts: <750,000/ml
- Antibiotic presence: negative

Storage time at plant max. 72h

Longer holding times allow growth of psychrophilic bacteria which can secrete heat-resistant proteases and lipases

Bacteria that limit milk shelf-life

- lipolytic and proteolytic psychrotrophs
  - heat resistant enzymes
  - ex. *Pseudomonas fluorescens*

- psychrotrophic spore formers (thermoducrics)
  - heat resistant spores
  - ex. *Bacillus cereus*

Thermization (Lewis and Heppell, 2000)

- 57-68°C for 15 seconds
- only effective if cooled to 4°C after treatment
- applied to raw milk that needs to be stored for several days prior to use
- purpose: reduce gram-negative psychrotrophic spoilage organisms (enzyme production)

Clarification and Clearing

Clarification: removal of small particles

- straw, hair etc. from milk; 2 lb/2,642 gal
- based on density

"Bactofugation": Centrifugal separation of microorganisms from milk:

- Bacteria and particularly spores have higher density than milk
- Two-stage centrifugation can reduce spore loads up to >99%
- Optimal temperature for clarification is 55-60ºC

Microfiltration

- Microfilter membranes of 1.4 μm or less can lead to reduction of bacteria
- and spores up to 99.5-99.99%.

Milk Fat Standardization/Decreaming

Separation of skim milk (about 0.05% fat) and cream (35-40% fat)

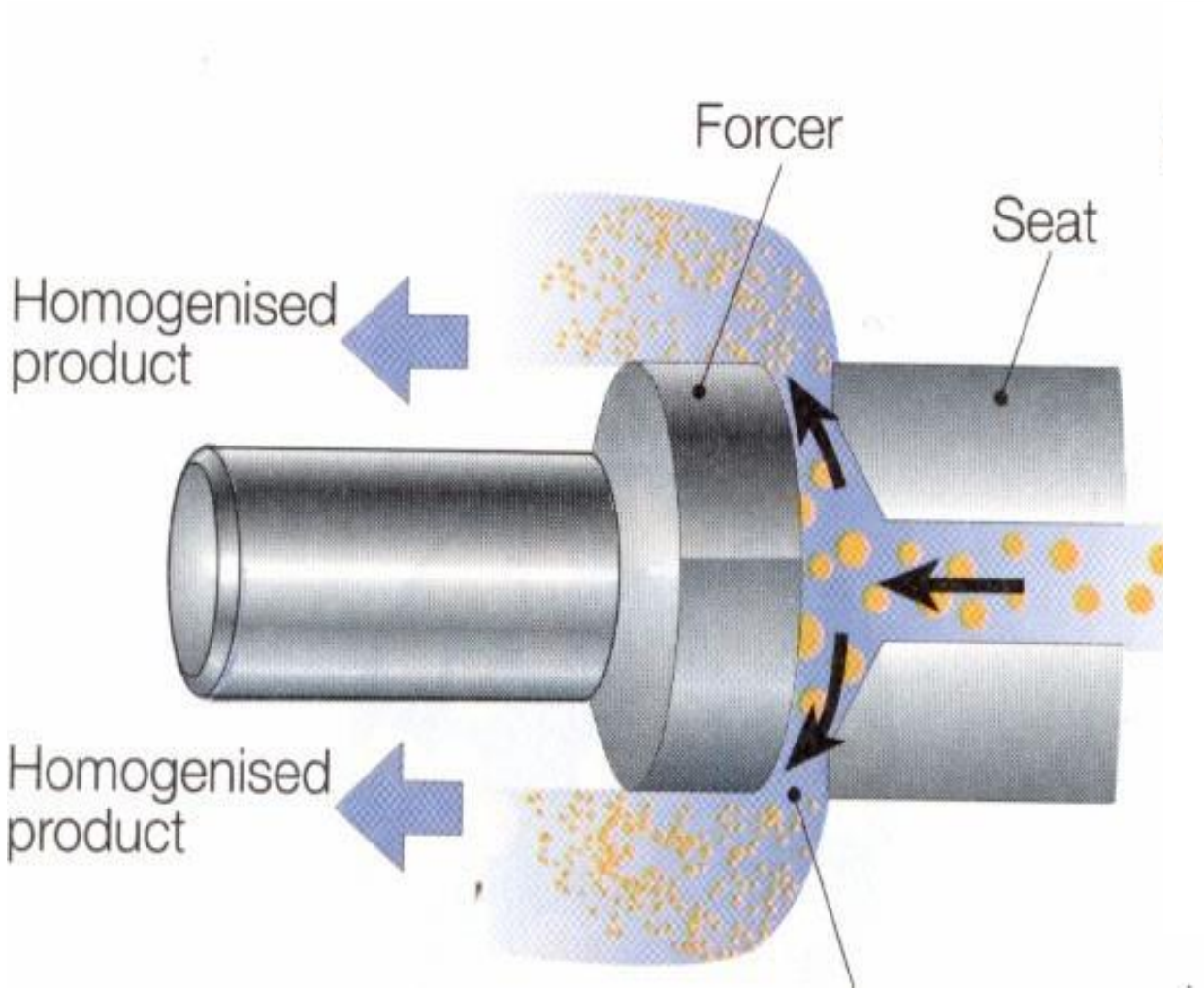
Based on the fact that cream has lower density than skim milk

Centrifugal separators are generally used today

Standardization of fat content: Adjustment of fat content of milk or a milk product by addition of cream or skim milk to obtain a given fat content

Homogenization

- Definition: Treatment of milk or a milk product to insure breakup of fat globules such that no visible cream separation occurs after 48 h at 40ºF (4.4ºC)
- Effects of homogenization:
  - No cream line formation due to smaller fat globules
  - Whiter color
  - More full-bodied flavor, better mouthfeel
- Process requirements:
  - Homogenization most efficient when fat phase is in a liquid state
  - Cream >12% fat cannot be homogenized at normal pressure, high pressure homogenization process is necessary
- Homogenization is a mechanical process where milk is forced through a small passage at high velocity



From the “Dairy Processing Handbook” 1995. Tetra Pak

Pasteurization

- Purpose: Inactivation of bacterial pathogens (target organisms *Coxiella burnettii*)
  - assurance of longer shelf life (inactivation of most spoilage organisms and of many enzymes)
- Pasteurization
  - Heat treatment of 72ºC (161°F) for 15 sec (HTST) or 63ºC (145°F) for 30 min (or equivalent)
  - does not kill all vegetative bacterial cells or spores (*Bacillus* spp. and *Clostridium* spp.)
  - Pasteurization temperature is continuously recorded

Efficacy of Pasteurization

- prior to pasteurization (1938) :
  milkborne outbreaks constituted **25%** all disease outbreaks

- Today: milk products associated with **< 1%**

Heat Treatment (Con't)

- Standards for Grade A pasteurized milk and milk products (PMO)
  - Temperature: Cooled to 45ºF or less
  - Bacterial counts: <20,000 cfu/ml
  - Coliform Counts: <10/ml
  - Phosphatase: < 1μg/ml
  - Antibiotic presence: negative

Heat Treatment (Con't)

- Ultra pasteurization: Thermal processing at 138ºC (280ºF) for at least 2 seconds
  - UP milk: ultrapasteurized and "non-aseptically" packaged, refrigerated storage
  - UHT milk: ultrapasteurized and aseptically packaged, storage at room temperature; avoid recontamination

- Standards for Grade A aseptically processed milk (UHT)
  - Temperature: none
  - Bacterial counts: no growth
  - Antibiotic presence: negative

Vitamin Fortification

- Preferably after separation
- Has to occur before pasteurization
- Can be continuous (using a metering pump) or batch addition

Filling/Packaging

- Functions of packaging:
  - Enable efficient food distribution
  - Maintain product hygiene
  - Protect nutrients and flavor
  - Reduce food spoilage
  - Convey product information
- Different containers:
  - Glass bottles (translucent vs. dark): can be reusable or recyclable
  - Plastic containers
  - Cartons
  - Plastic bags

Shelf Life of Heat Treated Fluid Milk

- Shelf life depends on:
  - Raw milk quality (bacterial and chemical quality)
  - Processing conditions
  - Post-processing storage
- Loss of taste and vitamins by light exposure:
  - Light-impermeable containers
- Extended Shelf life (ESL) milk
  - No single, specific definition of ESL
  - Pasteurized milk with a shelf life beyond the current typical shelf life of these products (10 - 14 days)
  - Generally involves measures to eliminate or minimize “post-pasteurization” contamination

Fermented Dairy products

- Fermented foods:
  - Food products produced by biological transformation (by bacteria or fungi)
  - Carbohydrate breakdown as a major characteristics (lactose ◊ lactate)

- Preservation: production of acids and alcohol (by “beneficial” bacteria) to inhibit spoilage bacteria and pathogens

Cheese:

- product made from the curd of the milk of cows (or other animals)

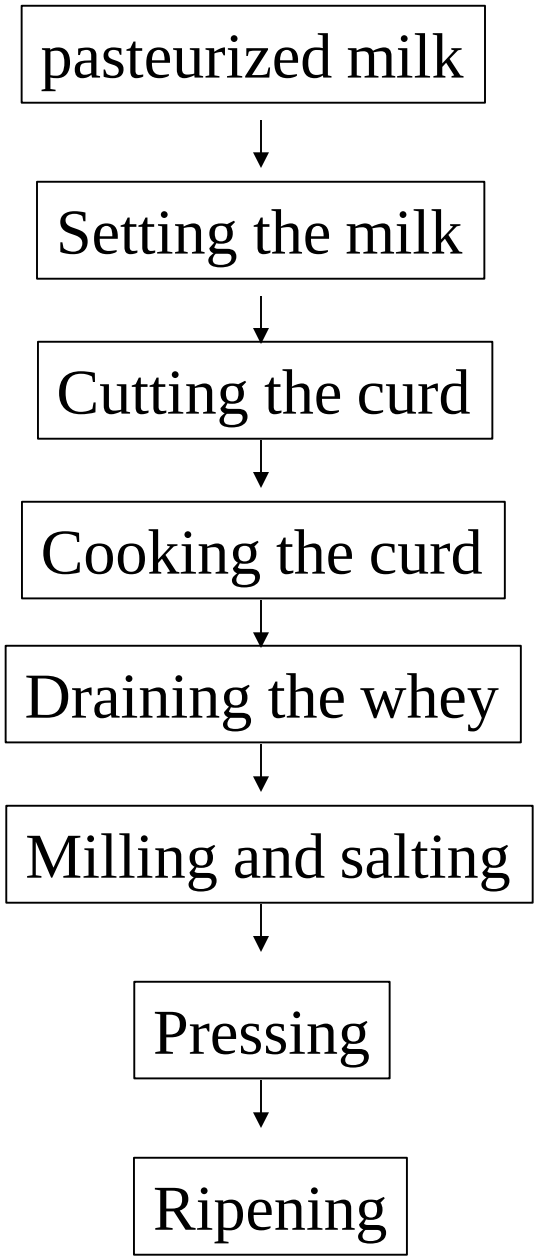
- casein coagulated by rennin and acid

- subsequent heating, salting, pressing, aging

Classification of Cheeses (Potter, 1995)

- Soft
  - unripened: cottage cheese, cream cheese
  - ripened: Brie, Camembert
- Semisoft
  - Munster, Limburger, Blue
- Hard
  - cheddar, swiss
- Very hard (grating)
  - Parmesan, Asiago
- whey cheeses (ricotta)
- processed cheese

Cheddar Cheese Making Process



Cheddar cheese making process

- starting ingredient: pasteurized whole milk
- setting the milk
    - while stirring heat to 31°C
    - add lactic-acid producing starter cultures
    - (add natural color)
    - add rennin to coagulate caseins and form curds
    - stop stirring and let set
- Cut the curd
    - increase surface area
    - release the whey

- Cooking (38°C for 30 minutes)
    - removes more whey
    - increases growth and acid production of cultures

Cheddar cheese making (cont.)

- Draining whey and matting the curd
  - remove excess whey
  - form curds into a slab
- cheddaring: cutting curd slab into blocks to allow excess whey to drain, and allow acidity to increase

- Milling and salting
  - cut curds into small pieces
  - 2.5% salt is added: drains whey, inhibits spoilage organisms and adds flavor

- Pressing to remove more whey
  - moisture content will affect bacterial growth and texture

- Ripening: bacteria develop flavor and texture over time

Ripening: flavor and texture development

- Primary proteolysis
  - 60 days; residual chymosin
  - caseins broken down into medium molec. wt. peptides

- secondary proteolysis
  - starter cultures break down peptides to lower molec. wts.

- Temperature: 5-7°C

- pH: 5.0 - 4.7
  - inhibits growth of spoilage organisms
  - inhibits enzyme activity

Cheese flavor development

- A complex, dynamic process
- Nature of the flavor evolves
- Proteolysis essential for full flavor development
  - Proteolytic enzymes
    - Allow LAB to utilize proteins present in milk to obtain essential amino acids necessary for growth
  - Generates peptides and amino acids
    - Impart flavor directly or serve as flavor precursors

Whey

- 100 lb of milk => 10 lb cheese + **90 lb whey**
  (NYS produces 3.6 billion lb/year)

- low solids, high lactose

- highly perishable (contains starter organisms)

- Acid whey: drained from cheese curd acidified to 4.6 by cultures (or acid); ex. Cottage cheese

- sweet whey: drained from curd formed by rennet coagulation ex. Cheddar

Whey Products

- concentrated and spray dried

- whey powder

- whey protein concentrates
  - different % purity
  - food ingredient

- lactose
  - food ingredient
  - fermented into alchohol

- whey cheeses

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