LIQUID MILK

PASTEURIZED MILK

Pasteurized beverage milk must be safe for the consumer and have a shelf life of a week or longer when kept refrigerated. Flavor, nutritive value, and other properties should deviate only slightly from those of fresh raw milk.

Major contaminants in raw milk:

- Pathogenic microorganisms, which may already be in the milk while in the udder, or be incorporated during or after milking. Most of these do not survive pasteurization, but they may also enter the product by recontamination.
- Toxicants taken up by the cow (e.g., with the feed) and entering the milk during its synthesis.
- Antibiotics, used to treat (the udder of) the cow.
- Disinfectants used on the farm or in the plant.
- Bacterial toxins formed during keeping of the milk.
- Other toxicants entering the milk by contamination during and after milking.
- Radionuclides.

Important manufacturing steps:

The importance of *thermalization* to prevent fat and protein breakdown by heat-resistant enzymes of psychrotrophic bacteria is discussed in Chapter 7 (see also Subsection 6.4). But as a rule, the keeping time of pasteurized milk is too short to cause noticeable decompositions by these enzymes, unless the original milk had a high count of psychrotrophs. Furthermore, thermalization at a rather high temperature (say 20 s at 67.5°C) causes a considerable inactivation of milk lipase (about 50%) and permits a somewhat lower pasteurization temperature in the manufacture of homogenized milk. Despite these obvious advantages of thermalization, dairy plants often only cool the milk (mainly to save on costs), taking the risk of some growth of psychrotrophs.

Separation is needed to adjust to the desired fat content. If homogenization is omitted, only a part of the milk will be skimmed, while the skim milk volume obtained should suffice to standardize the milk.

Homogenization serves to prevent the formation of a cream layer in the package during storage. Many users dislike such a layer. In low-pasteurized milk (alkaline phosphatase just inactivated), a loose cream layer of agglutinated fat globules forms that can be easily redispersed throughout the milk. In high-pasteurized milk, the cold agglutinin has been inactivated and a cream layer forms far more slowly, but then it is a compact, hardly dispersible layer; a solid cream plug may even result from partial coalescence of the fat globules. Therefore, this milk is usually homogenized. As a rule, not all of the milk is homogenized but only its cream fraction (partial homogenization) to reduce cost. Obviously, all milk should then be separated. Homogenization clusters should be absent after the homogenization; therefore, the fat content of the cream should be rather low (10% to 12%) and the homogenizing temperature not too low (≥55°C); moreover, two-stage homogenization should be applied (see Chapter 9). Usually the homogenization precedes the pasteurization to minimize the risk of recontamination. Because milk lipase then is still present, the milk should immediately be pasteurized.

After partial homogenization the milk may still cream due to cold agglutination. This results from the agglutinin in the skim milk after warm separation being not fully inactivated by the subsequent pasteurization (see Figure 16.2). In spite of a low ratio of agglutinin to fat surface area, the fat globules can agglutinate if the raw milk contained much agglutinin.

Homogenized milk has an increased tendency to foam, especially at low temperature.

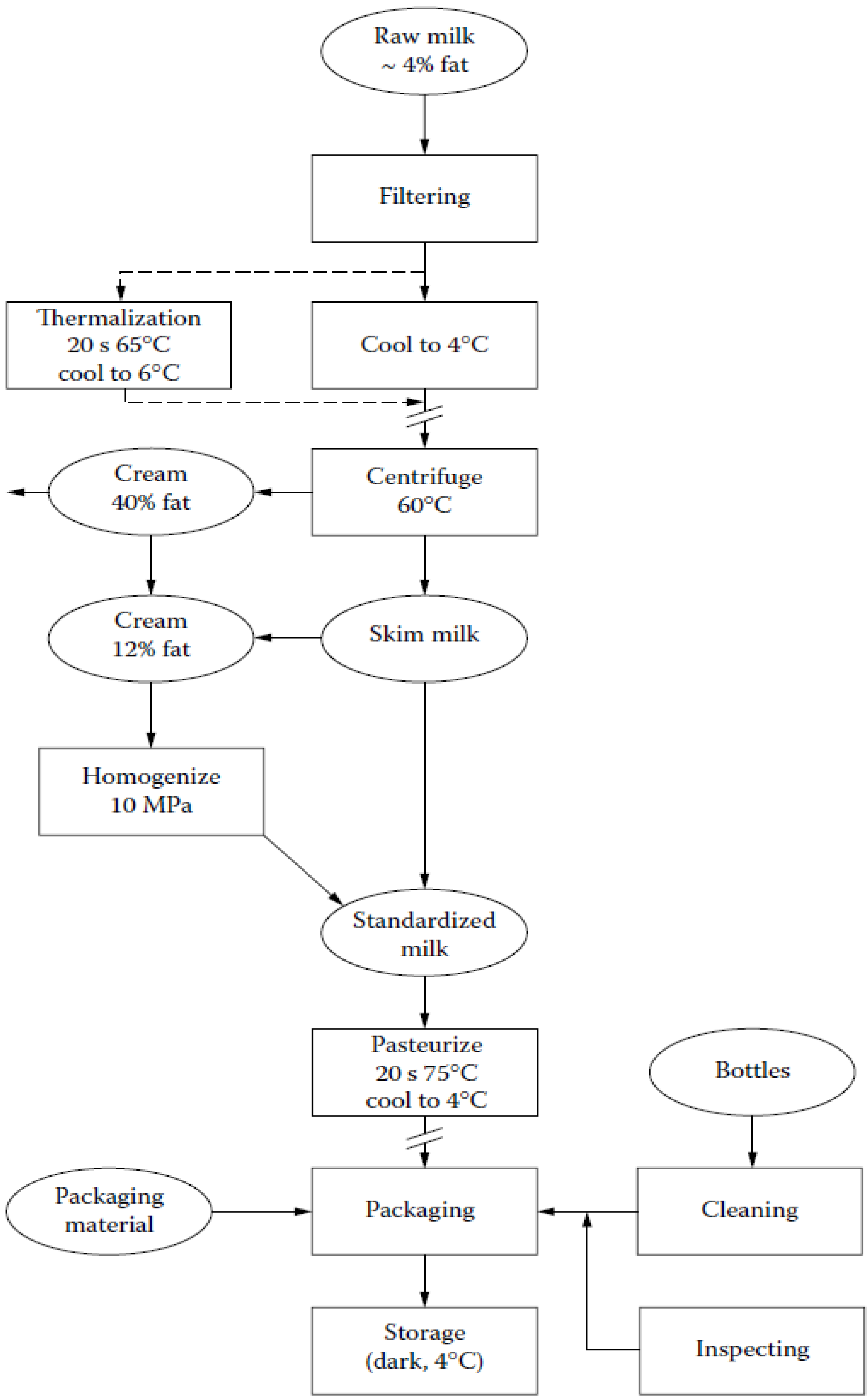
Standardization with respect to fat content is described in Section 6.5. It can be done by adding skim milk (or cream) to the milk in the storage tank or by continuous standardization.

Pasteurization ensures the safety and greatly enhances the shelf life of the product. See Subsection 7.3.4 for the kinetics of killing bacteria. A mild heat treatment, e.g., 15 sec at 72°C, kills all pathogens that may be present (especially *Mycobacterium tuberculosis*, *Salmonella* spp., enteropathogenic *E. coli*, *Campylobacter jejuni*, and *Listeria monocytogenes*) to such an extent that no health hazard is left. Some cells of some strains of *Staphylococcus aureus* can survive the heat treatment, but they do not grow to the extent as to form hazardous amounts of toxins. Such pasteurization inactivates alkaline phosphatase to the extent as to be no longer detectable (the enzyme may, however, regenerate slightly after keeping the product for some days, but this is especially true of pasteurized cream). Most of the spoilage microorganisms in raw milk, such as coliforms, mesophilic lactic acid bacteria, and psychrotrophs, are also killed by low pasteurization. Among those not killed are heat-resistant micrococci (*Microbacterium* spp.), some thermophilic streptococci, and bacterial spores. But these microorganisms do not grow too quickly in milk, except *Bacillus cereus*. The latter organism is pathogenic if present in large numbers, but prior to this the milk has become undrinkable because of its off-flavor.

Packaging of low-pasteurized beverage milk is generally done in single-service containers such as cartons. A certain quantity of milk is still filled in glass or plastic bottles (see Chapter 15). Great care should be taken to ensure hygiene during packaging in terms of the safety of the product, but especially because of the effect of recontamination on the shelf life of the product; aseptic packaging would be desirable. The temperature of the milk may increase by about 1 K during packaging due to the transportation in pipelines and on conveyor belts, and due to the use of sealing machinery. Because recooling of packaged products is slow, especially if piled up closely, such temperature increase should be anticipated by deeper cooling after pasteurization.

Major changes during shelf-life / storage

- Decomposition by bacteria growing in the milk, such as acid production, protein breakdown, and fat hydrolysis
- Decomposition by milk enzymes or by extracellular bacterial enzymes, like fat and protein breakdown
- Chemical reactions causing oxidized or sunlight flavor
- Physicochemical changes such as creaming, flocculation, and gel formation, which may, in turn, be caused by the above-mentioned changes



Flow sheet for manufacturing of pasteurized milk