MILK POWDER

Objectives:

1. The main purpose of the manufacture of milk powder is to convert the liquid perishable raw material to a product that can be stored without substantial loss of quality, preferably for some years. Decrease in quality mainly concerns formation of gluey and tallowy flavors (due to Maillard reactions and autoxidation, respectively) and decreasing nutritive value (especially decrease in available lysine). If the water content becomes very high and the storage temperature is high, caking (due to lactose crystallization) and enzymic and even microbial deterioration can occur; however, such problems are avoidable.
2. The powder should be easy to handle. It should not dust too much or be overly voluminous. It should be free-flowing, i.e., flow readily from an opening, and not stick to the walls of vessels and machinery. The latter requirement is especially important for powder used in coffee machines, etc.
3. After adding water the powder should be reconstituted completely and readily to a homogeneous mixture, similar in composition to the original product. Complete reconstitution means that no undissolved pieces or flakes are left and that neither butter grains nor oil droplets appear on top of the solution. 'Readily reconstituted' means that during mixing of powder and water no lumps are formed, because these are hard to dissolve. In the ideal situation the powder will disperse rapidly when scattered on cold water; this is called *instant powder*. Special processing steps are needed to achieve this property. The importance of instant properties closely depends on the kind of application.
4. According to its intended use the reconstituted product should meet specific requirements. If the use is beverage milk, the absence of a cooked flavor is of importance. If the powder is to be used for cheese making, the milk should have good clotting properties. If used to make recombined evaporated milk, satisfactory heat stability is necessary. So there

are several widely divergent requirements that cannot be reconciled in one powder. For instance, it is not possible to make whole milk powder that has no cooked flavor and at the same time develops no oxidized flavor during storage. With respect to the intensity of the heat treatment, milk powders are classified as low-, medium-, or high-heat (Subsection 20.4.6).

5. The product must be free of health hazards, be it toxic substances or pathogenic organisms. Besides general hygienic measures and checks prevailing in the dairy industry, there are some specific considerations.

Approximate Composition (% w/w) of Some Types of Powder

	Powder From			
Constituent	**Whole Milk**	**Skim Milk**	**Whey**	**Sweet-Cream Buttermilk**
Fat	26	1	1	5
Lactose	38	51	72–74	46
Casein	19.5	27	0.6	26
Other proteins	5.3	6.6	8.5	8
'Ash'	6.3	8.5	8	8
Lactic acid	—	—	0.2–2	—
Water	2.5	3	3	3

Important manufacturing steps

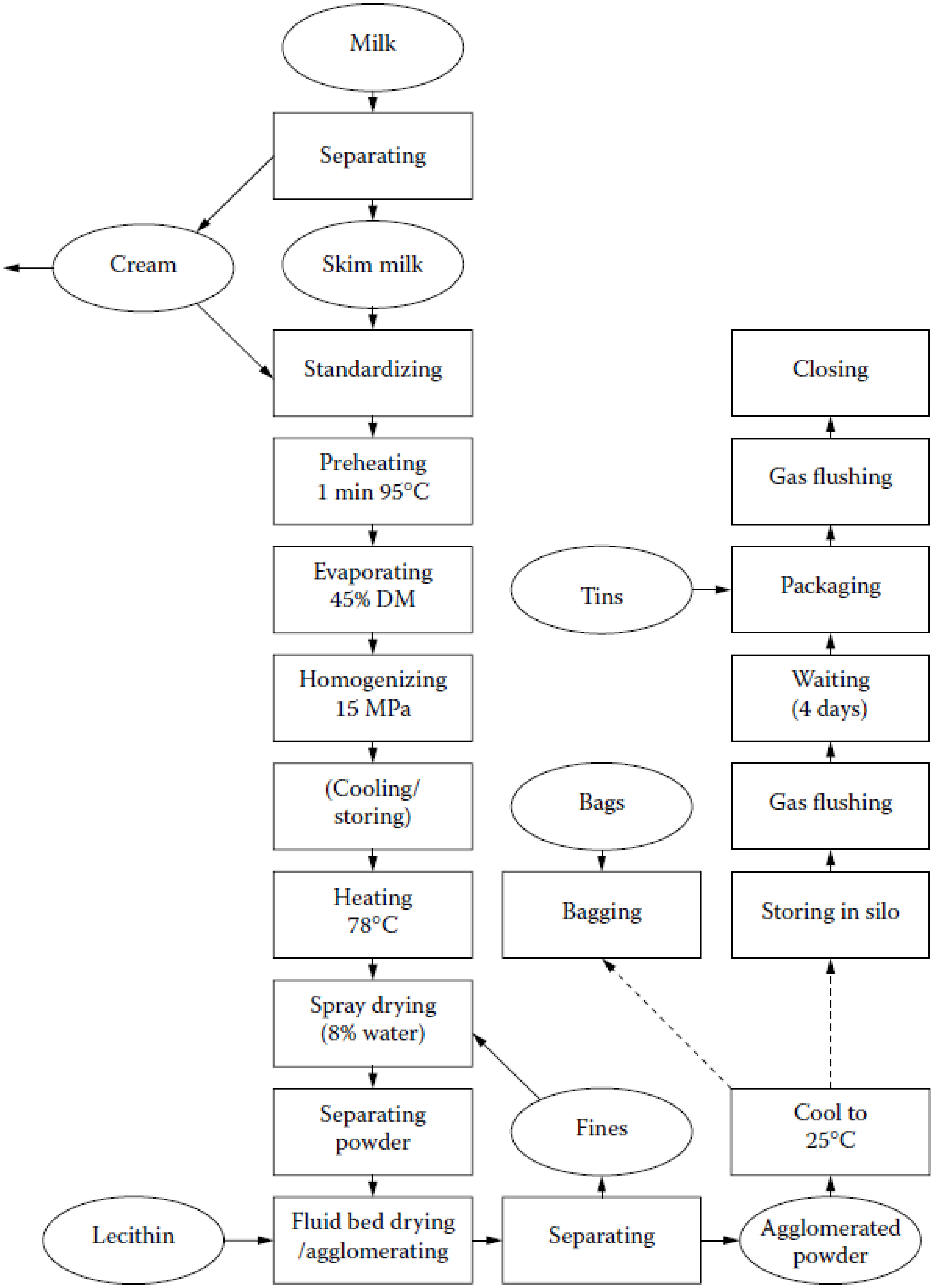
Figure 20.1 gives a flow sheet for the manufacture of whole milk powder. Many steps involved will be self-evident. Intense pasteurization is needed to obtain resistance to autoxidation. The concentrate is not always homogenized, especially if atomization is done by means of a nozzle, because the fat globules are effectively disrupted in the nozzle (Subsection 10.4.2). Homogenization of highly concentrated milk considerably increases its viscosity (because the transfer of large casein micelles to the fat globules gives the latter such an irregular shape as to increase the effective volume fraction of fat globules plus casein micelles). This increase leads to coarser droplets during atomization, with all drawbacks involved (Subsection 10.4.2). Consequently, if the concentrated milk is not homogenized, evaporation can continue up to a higher dry-matter content. Storage (buffering) of the concentrate before atomization is not always applied; it is done mainly to overcome differences in capacity between evaporator and drier. However, the concentrate should not be kept warm for more than a short time to prevent the growth of microorganisms. A refrigerated concentrate generally is too viscous to be atomized readily, and it is therefore heated. The latter must be done just prior to atomization because otherwise the viscosity increases again (age thickening) (see, for example, Figure 10.10C). The heating can at the same time serve to kill bacteria that may have recontaminated the concentrate.

Lecithinizing during the drying in the fluid bed is not always applied; it is meant to obtain instant properties (Subsection 20.4.5.1). The so-called gas flushing, essentially displacing air by N_2 or a mixture of N_2 and CO_2, is to remove a considerable part of the oxygen and thereby to improve the stability toward autoxidation (Section 20.5); it can be done once or twice. If it is not done, the powder may be packaged into multilayer paper bags with a polyethylene inner layer. Whole milk powder, however, is often packaged in tins or in plastic containers to minimize oxygen uptake.

For the manufacture of *skim milk powder* the pasteurization can be less intense (at least phosphatase negative), according to the intended application (Subsection 20.4.6). Homogenization is omitted, and the milk can be concentrated to a somewhat higher solids content. Nor are lecithinizing and gas flushing carried out. Sometimes vitamin preparations are added, especially vitamin A. This can be achieved by dry mixing afterward, or by emulsifying a concentrated solution of vitamin A in oil into a part of the skim milk.

The manufacture of *whey powder* is largely similar to that of skim milk powder. At first, curd fines should be removed from the whey by filtration or by means of a hydrocyclone, and the whey should be separated. A problem is the processing of sour whey, which causes rapid fouling of the machinery. Sour whey (or skim milk) can be neutralized with alkali.

Whey can be evaporated to at least 60% dry matter, but then crystallization of lactose readily occurs (see Figure 10.11). An alternative operation is to allow the lactose in the evaporated whey to crystallize as completely as possible, e.g., by keeping it for 3 h at 25°C while stirring. If the dry-matter content is over 60%, seeding with lactose crystals is not necessary. Atomization should be with a disk, as a spray nozzle would become blocked. The precrystallized whey powder then obtained has some attractive properties, especially in regard to caking (Section 20.5). An additional advantage for the manufacturer is the higher yield: The conventional methods for determining the water content of powders do not remove the bulk of the water of crystallization of α-lactose monohydrate; crystallization of 80% of the lactose yields up to a maximum of 3% more whey powder. In this way precrystallized skim milk powder also can be made, but then a longer crystallization time and seeding with lactose crystals are needed.



FLOW SHEET FOR MANUFACTURING OF MILK POWDER (FROM WHOLE MILK)