Chapter 17

Milk powder

The method of preserving various foodstuffs by drying them, and thereby depriving micro-organisms of the water necessary for their growth, has been known for centuries. According to Marco Polo's accounts of his travels in Asia, Mongolians produced milk powder by drying milk in the sun.

Today milk powder is produced on a large scale in modern plants. Skimmilk powder has a maximum shelf life of about 3 years. Whole milk powder has a maximum shelf life of about 6 months. This is because the fat in the powder oxidises during storage, with a consequent gradual deterioration in taste.

Drying

Drying means that the water in a liquid product – in this case milk – is removed, so that the product acquires a solid form. The water content of milk powder ranges between 2.5 and 5%, and no bacteria growth occurs at such a low water content. Drying extends the shelf life of the milk, simultaneously reducing its weight and volume. This reduces the cost of transporting and storing the product.

Freeze-drying has been used to produce high-quality powder. In this process the water is evaporated from the milk under vacuum. This method offers advantages from the quality aspect, as the protein fraction is not affected. The powder will always be affected to a greater or lesser extent if drying is carried out at a higher temperature. Freeze-drying is not however widely used, partly because of the high energy demand.

Commercial methods of drying are based on heat being supplied to the product. The water is evaporated and removed as vapour. The residue is the dried product – the milk powder. Two principal methods are used for drying in the dairy industry: *roller drying* and *spray drying*. In spray drying, the milk is first concentrated by evaporation and then dried in a spray tower.

During the first stage of drying the excess water, in free form between the particles of the dry solids, is evaporated. In the final stage the water in pores and capillaries of the solid particles is also evaporated.

The first stage is relatively fast, whereas the last stage demands more energy and time. The product will be significantly affected by the heat if this drying is carried out in such a way that milk particles are in contact with the hot heat transfer surfaces – as in the case of roller drying. The powder may then contain charred particles which impair its quality.

Various uses of milk powder

Dried milk is used for many applications, such as:

- recombination of milk
- mixing into dough in the bakery industry to increase the volume of the bread and improve its water-binding capacity. The bread will then remain fresh for a longer period of time.
- mixing into pastry dough to make it crisper
- as a substitute for eggs in bread and pastries
- producing milk chocolate in the chocolate industry
- producing sausages and various types of ready-cooked meals in the food industry and catering trade
- as a substitute for mother's milk in baby foods
- production of ice-cream
- animal feed

Table 17.1

Extra grade skimmilk powder

(ADMI* specification for skimmed milk powder)

Property	Spray dried not exceeding	Roller dried not exceeding
Milk fat content	1.25 %	1.25 %
Moisture content	4.00 %	4.00 %
Titratable acidity, l.a.	0.15 %	0.15 %
Solubility index	1.25 ml **	15.00 ml
Bacterial estimate	50 000 per gram	50 000 per gram
Scorched particles	Disc B (15.0 mg)	Disc C (22.5 mg)

* ADMI = American Dry Milk Institute Inc. (This institution has also published "Standards For Grades of Dry Milks including Methods of Analysis").

** Except powders designated as "high-heat" (HH), for which the permitted maximum is 2.0 ml.

Skimmilk powder

Skimmilk powder is by far the most common type of milk powder.

Each field of application makes its own specific demands on milk powder. If the powder is to be mixed with water in recombined milk for consumption, it must be easily soluble and have the correct taste and nutritive value. Some degree of caramellisation of the lactose is beneficial in chocolate production. In the first case gentle drying of the product in a spray tower is essential, whereas in the second case the powder must be subjected to intense heat treatment in a roller dryer. Two types of powder are therefore distinguishable:

1 roller dried powder
2 spray dried powder

Table 17.1 shows an example of the standards applicable to skimmilk powder. The solubility of spray powder is very good, whereas that of roller dried powder is appreciably poorer, on account of the intense heat treatment in roller drying.

Depending on the intensity of the heat treatment, milk powder is classified into categories related to the temperature/time combinations the skimmilk has been exposed to prior to evaporation and drying.

Heat treatment denatures whey proteins, the percentage denaturated increasing with the intensity of heat treatment. The degree of denaturation is normally expressed by the Whey Protein Nitrogen Index (WPNI) as milligrams of undenatured whey protein (u.w-p) per gram of powder.

Information about various categories of spray dried skimmilk powder is summarised in Table 17.2.

Table 17.2
Categories of spray dried skimmilk powder.

Category	Temp/time	WPNI mg/g u.w-p
Extra low-heat	<70°C	*
Low-heat (LH) powder	70°C/15 s	> 6.0
Medium-heat (MH) powder	85°C/20 s	5 – 6.0
”	90°C/30 s	4 – 5.0
”	95°C/30 s	3 – 4.0
Medium high-heat (HH)	124°C/30 s	1.5 – 2.0
High-heat (HH)	appr. 135°C/30 s	<1.4
High-heat high stable (HHHS) (from selected milk)	appr. 135°C/30 s	<1.4

* Not measurable

Table by Sanderson N.Z., J. Dairy Technology, 2, 35 (1967)

Whole milk powder

Spray dried whole milk powder is nomally produced from fat standardised milk. After standardisation the milk need not be homogenised provided that it is thoroughly agitated, without air inclusion, before evaporation and again between evaporation and spray drying. The concentrate is however homogenised in certain cases for production of instant whole milk.

Fat standardised milk for production of roller dried powder is normally homogenised.

Whole milk powder, unlike skimmilk powder, is not categorised. Milk intended for whole milk powder is normally pasteurised at 80 – 85°C to inactivate most of the lipolytic enzymes that would otherwise degrade the milk fat during storage.

Instant-milk powder

Special methods for the production of both skimmilk and whole milk powder with extremely good solubility – known as instant powder – are also available. This powder has a larger grain size, influenced by agglomeration, than normal spray powder and dissolves instantly even in cold water.

Bulk density

When powders are shipped over long distances it is important that they have a high bulk density to reduce the volume, since in most cases transportation costs are calculated by volume. A high bulk density also saves packaging material. However, in some instances the producers may be interested in low bulk density to supply optically larger amounts of powder than that of their competitors. Low bulk density, as influenced by agglomeration, is also an important characteristic of instant powders.

Definition

Bulk density is the weight of a unit volume of powder; in practice it is expressed as g/ml, g/100 ml or g/l.

Factors influencing bulk density

The bulk density of milk powders is a very complex property; it is the result of several other properties and is influenced by a number of factors. The primary factors determining bulk density are:

1 The particle density, given by :
- powder material density
- the content of the occluded air inside the particles

2 The content of interstitial air, i.e. the air between the particles.

Powder material density

The powder material density is given by the composition of the powder. It depends on the contents and densities of the individual components, and can be calculated according formula:

$$\frac{100}{\frac{\%\,A}{D_A} + \frac{\%\,B}{D_B} + \frac{\%\,C}{D_C} + \text{ etc. } + \text{ \% moisture}}$$

% A, % B, % C are equivalent to the percentages of the components having densities D_A, D_B, D_C.

Occluded air content

Milk powder normally contains between 10 and 30 ml of entrapped air per 100 g of powder. There are many factors influencing the occluded air in powder particles.

Some of these factors will just be touched upon below:

- Incorporation of air into the feed. The concentrate is effectively deaerated by evaporation, but when it is transferred to the spray dryer it may pick up air from leaking pipelines, etc.
- The system chosen for spraying the concentrate into the dryer.
- The properties of the feed. The amount of air incorporated into the product depends not only on the intensities of whipping action before or during atomisation, but also on the properties of feed, i.e. the ability of the feed to form stable foam. This property is mainly influenced by the content and state of proteins and the possible presence of whipping inhibitors. Thus concentrates which contain fat are much less prone to foaming than skimmilk. The following factors influence the foaming properties of skimmilk in the drying process:

- Undenatured whey proteins have a great tendency to foam; this can be reduced by heat treatment proportional to the degree of denaturation, see Table 17.2.
- Concentrates with a low total solids content foam more than highly concentrated feeds.
- Cold concentrates are more easily whipped than warm ones.

Interstitial air
The air content between the particles, the interstitial air, may amount to about 127 ml/100 g of powder. This is a very complex property which depends for example on the particle size distribution and the degree of agglomeration.

Production of milk powder

In the production of *roller dried* powder, the pre-treated milk is admitted to the roller dryer and the whole drying process takes place in one stage.

In the production of *spray dried* powder, the milk is first evaporated under vacuum to a DM content of about 45 – 55%. Spray dried skimmilk powder is manufactured in two basic qualities:
- ordinary product and
- agglomerated product (instant milk powder) by various spray drying systems.

Following both roller and spray drying, the powder is packed in cans, paper bags, laminated bags or plastic bags, depending on the quality and the requirements of the consumers.

Raw material

Very strict demands are made on the quality of the raw material for production of milk powder. Table 17.1 shows that the number of bacteria per gram of powder must not exceed 50 000, or even 30 000 in some countries. This corresponds to about 5 000 (or 3 000) bacteria per litre of reconstituted product, provided that no reinfection occurs. Since spray powder production involves vacuum evaporation, it is just as important as in the production of condensed milk to keep heat-resistant bacteria under control so that they will not multiply during evaporation. *Bactofuge* treatment or *microfiltration* is therefore also used in powder production to remove bacteria spores from the milk, thereby improving the bacteriological quality of the end product.

Strict demands are made on the quality of the raw material for production of milk powder.

Milk for powder production must not be subjected to excessive, intense heat treatment prior to delivery to the milk powder plant. Such heat treatment would cause the whey protein to coagulate, and the solubility, aroma and taste of the milk powder would be impaired. The milk is subjected to the peroxidase test or the whey protein test to determine whether the preceding heat treatment was too intense. Both of these tests indicate whether or not the milk was previously pasteurised at a high temperature.

General pre-treatment of the milk

In the production of *skimmilk powder* the milk is clarified in conjunction with fat separation. This is also the case if the fat content is standardised in a direct standardisation system. Standardised milk used for producing *whole milk powder* is not normally homogenised unless it is to be roller dried.

Skimmilk intended for powder production must be pasteurised at least to a negative phosphatase test. In the production of dried *whole milk* the heat treatment must be so intense that the lipases will also be inactivated. This normally involves high-temperature pasteursation to a negative peroxidase test.

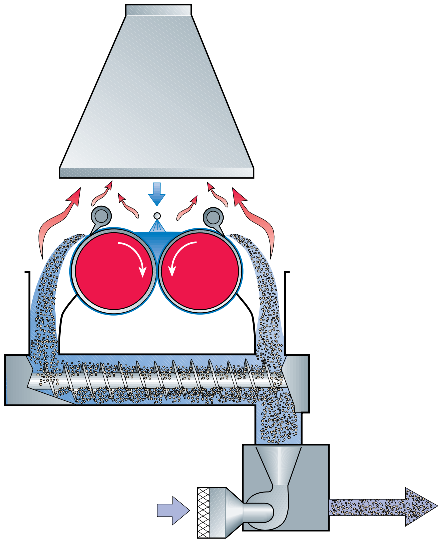


Fig. 17.1 *Principle of the trough-fed roller dryer.*

Milk
Heating medium
Air for pneumatic transportation and cooling

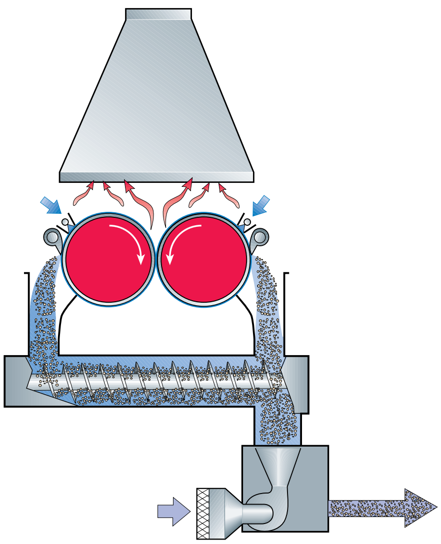


Fig. 17.2 *Principle of the spray-fed roller dryer.*

Milk
Heating medium
Air for pneumatic transportation and cooling

Roller or drum drying

In roller drying the milk is distributed on rotating, steam-heated drums. The water in the milk evaporates and is drawn off by a flow of air when it comes in contact with the hot drum surface. The high temperature of the heating surfaces converts the protein to a form which is not easily soluble and which discolours the product.

Intense heat treatment increases the water-binding properties of the powder. This characteristic is useful in the prepared-food industry.

The distinction between *trough-fed* and *spray-fed* roller dryers is based on the manner in which the milk is fed on to the drums.

Figure 17.1 shows the principle of the *trough-fed* roller dryer. The pre-treated milk is admitted to a trough formed by the cast iron drums and their end walls. A thin layer of milk on the drums is heated quickly when it comes in contact with the hot surface. The water is evaporated and the layer of milk on the drum dries. This film is continuously scraped off by knives in contact with the periphery of each drum.

The dried milk falls into a screw conveyor in which it is ground into flakes. The flakes are then transferred to a grinder, and hard and burned particles are separated on a screen at the same time.

Depending on capacity, the double roller dryer is 1 – 6 m long and has a drum diameter of 0.6 – 3 m. The size depends on film thickness, temperature, drum speed and the required DM content of the dried product.

The thickness of the dry layer can be varied by adjusting the gap between the drums.

Figure 17.2 shows the principle of the spray-fed roller dryer. Nozzles above the drums spray a thin film of pre-treated milk on the hot surfaces of the drums. In this arrangement almost 90% of the heat transfer area is utilized, as opposed to less than 75% in the trough-fed dryer.

The film thickness is determined by the supply pressure to the spray nozzles. The drying time can also be controlled by adjusting the temperature and the speed of the drums. This provides some scope for controlling the characteristics of the powder. If the parameters are correct, the milk film should be almost dry when it is scraped off the drums.

The dry film scraped off the drums is subjected to the same treatment as for the trough-fed dryer.

Spray drying

Spray drying is carried out in two phases. In the *first phase* the pre-treated milk is *evaporated* to a DM content of 45 – 55%. In the *second phase* the concentrate is pumped to a *drying tower* for final drying. This process takes place in three stages:

- Dispersion of the concentrate into very fine droplets.
- Mixing of the finely dispersed concentrate into a stream of hot air which quickly evaporates the water.
- Separation of the dry milk particles from the drying air.

Evaporation is a necessary production stage for high-quality powder. Without prior concentration the powder particles will be very small and will have a high air content, poor wettability and a short shelf life. The process will then also be uneconomical.

Falling-film evaporators are generally used for concentration, which is carried out in two or more stages to a DS content of 45 – 55%. The equipment is the same as that used in the production of condensed milk.

Basic drying installations

Single-stage drying

The most simple installation for making ordinary powder is the spray dryer with a pneumatic conveying system, figure 17.3.

This system works on the *single-stage* drying principle, which means

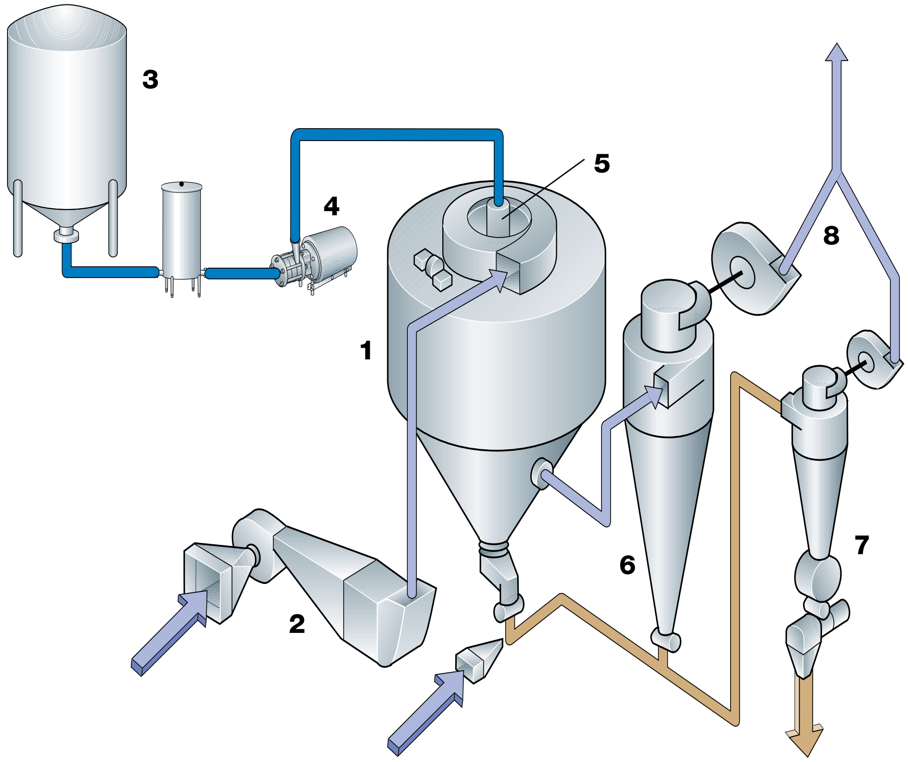


Fig. 17.3 *Conventional spray dryer (one-stage drying) with conical base chamber.*
1 Drying chamber
2 Air heater
3 Milk concentrate tank
4 High pressure pump
5 Atomiser
6 Main cyclone
7 Transport system cyclone
8 Air suction fans and filters

Milk
Air
Powder

that all removal of moisture from the concentrate to the required final moisture content takes place in the spray drying chamber (1). The subsequent pneumatic conveying system serves only to collect the powder leaving the chamber cone together with the powder fraction separated from the exhaust air in the main cyclone (6), to cool the powder and feed it via the final cyclone (7) to the bagging-off hopper.

Two-stage drying

In a *two-stage* drying system producing the same type of powder as the previously mentioned installation, the pneumatic conveying system is replaced by a fluid bed dryer, the working principle of which is discussed below under the heading "Operating principle of spray drying".

Three-stage drying

Three-stage drying is an extension of the two-stage concept developed to achieve even greater savings in plant operation costs.

Operating principle of spray drying

Single-stage drying

Figure 17.3 shows the arrangement of a single-stage drying plant. The milk concentrate is fed to the drying chamber (1) by a high-pressure pump (4), and then continues to the atomiser (5). The very small milk droplets are sprayed into the mixing chamber, where they are mixed with hot air.

Air is drawn in by a fan through a filter and supplied to a heater (2), where it is heated to 150 – 250°C. The hot air flows through a distributor to a mixing chamber. In the mixing chamber the atomised milk is mixed thoroughly with the hot air and the water in the milk is evaporated. Most of the drying takes place as the droplets are decelerated by air friction following release from the atomiser at high velocity. The free water evaporates instantaneously. The water in the capillaries and pores must first diffuse to the surfaces of the particles before it can be evaporated. This takes place as the powder slowly settles in the spray tower. The milk is only heated to 70 – 80°C because the heat content of the air is continuously consumed by evaporation of water.

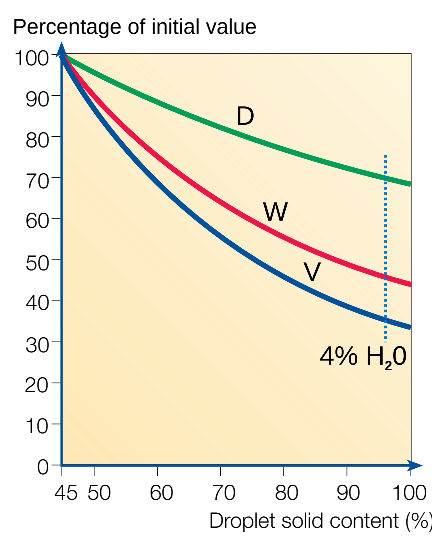


Fig. 17.4 *Weight, volume and diameter decrease of droplet under ideal drying conditions down to 4% H_2O.*
D = Diameter
W = Weight
V = Volume

Loss of water from the droplets leads to a considerable reduction in weight, volume and diameter. Under ideal drying conditions, weight will decrease to about 50%, volume to about 40%, and the diameter to about 75% of the droplet size produced by release from the atomiser, figure 17.4.

During the drying process the milk powder settles in the drying chamber and is discharged at the bottom. It is conveyed pneumatically to the packing section by cooling air which is drawn into the conveyor duct by a fan. After cooling, the mixture of cooling air and powder flows to the discharge unit (7), where the powder is separated from the air before being packed.

Some small, light particles may be mixed with the air that leaves the drying chamber. This powder is separated in one or more cyclones (6, 7). After separation the powder is returned to the main stream of milk powder on the way to packing. The cleaned drying air is extracted from the plant by a fan.

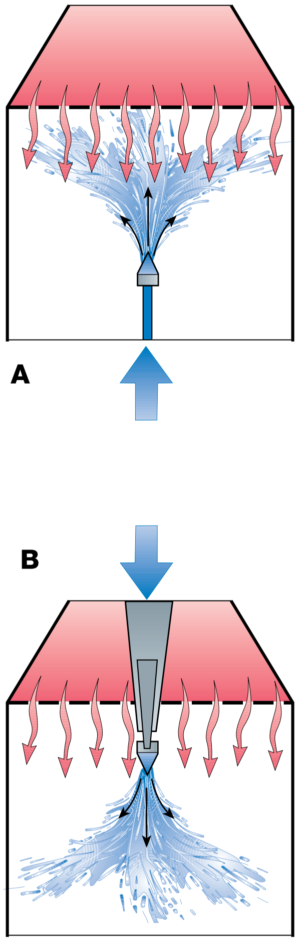


Fig. 17.5 *Stationary nozzles for atomising the milk in a spray drying chamber.*
A Counterflow nozzle
B Nozzle discharging in the direction of the air flow

Milk atomising

The more finely dispersed the milk droplets, the larger their specific area will be and the more effective the drying. One litre of milk has a surface area of about 0.05 m^2. If this quantity of milk is atomised in the spray tower, each of the small droplets will have a surface area of 0.05 – 0.15 mm^2. The total surface area of all the milk droplets from the original litre of milk will be about 35 m^2. Atomising thus increases the specific area about 700 times.

The design of the atomising equipment depends on the particle size and the properties required of the dried product. These properties can be granularity, texture, solubility, density and wettability. Certain dryers have stationary nozzles, see figure 17.5. The arrangement in figure 17.5 A is used in low spray towers and is located so that the relatively large milk droplets will be discharged in counterflow in relation to the drying air. A stationary nozzle which discharges the milk in the same direction as the air flow is shown in figure 17.5 B. In this case the milk feed pressure determines the particle size. At high feed pressures (up to 30 MPa or 300 bar) the powder will be very fine and have a high density. At low pressures (20 – 5 MPa or 200 – 50 bar) the particle sizes will be larger and there will be no dust-size particles.

Figure 17.6 shows another very common type of atomiser, consisting of a rotating disc with passages from which the milk is ejected at high velocity. In this case the properties of the product are controlled by the speed of rotation of the disc. It can be varied between 5 000 and 25 000 r/min.

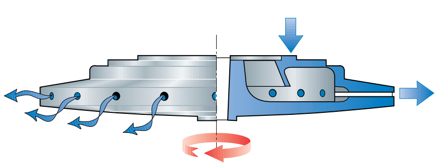


Fig. 17.6 *Rotating disc for atomising milk in the spray drying chamber.*

Two-stage drying

The last traces of moisture are the most difficult to remove, unless high outlet drying temperatures are used to provide a sufficient driving force. As elevated outlet drying temperatures can have a detrimental effect on powder quality, it is essential to operate at lower outlet temperatures with dairy products. If the moisture content of the resulting powder is still too high, an after-drying stage is incorporated after the spray dryer in a two-stage process as illustrated in figure 17.7.

Two-stage drying methods for producing powdered milk product combine spray drying as the first stage and fluid bed drying as the second stage.

The moisture content of the powder leaving the chamber is 2 – 3 per cent higher than the final moisture content. The function of the fluid bed dryer is to remove excess moisture and finally to cool the powder down.

Drying of milk in two stages was originally developed to obtain agglomerated powders in straight-through processing, but in the early seventies was adopted for non-agglomerated powders so that the advantage of product quality improvement could be combined with the better process economy of two-stage processing.

The powder from both single-stage and two-stage installations consists predominantly of single particles; it is dusty and difficult to reconstitute. There are however some slight differences. Two-stage dried powder is coarser due to bigger primary particles and the presence of some agglomerates. Consequently it is not so dusty and can be reconstituted more easily. However, the biggest difference between these two powders is in the properties that are influenced by heat exposure during drying.

The properties in question are the solubility index and the content of occluded air, both lower, and bulk density, which is higher. The droplet temperature just after atomisation is low, just slightly above the wet bulb temperature of the drying air. The particle temperature increases gradually with progressive water removal, finally achieving a temperature which is below the outlet air temperature – how much lower depends on the moisture content of the particles.

The one-stage and two-stage drying systems are compared in table 17.3.

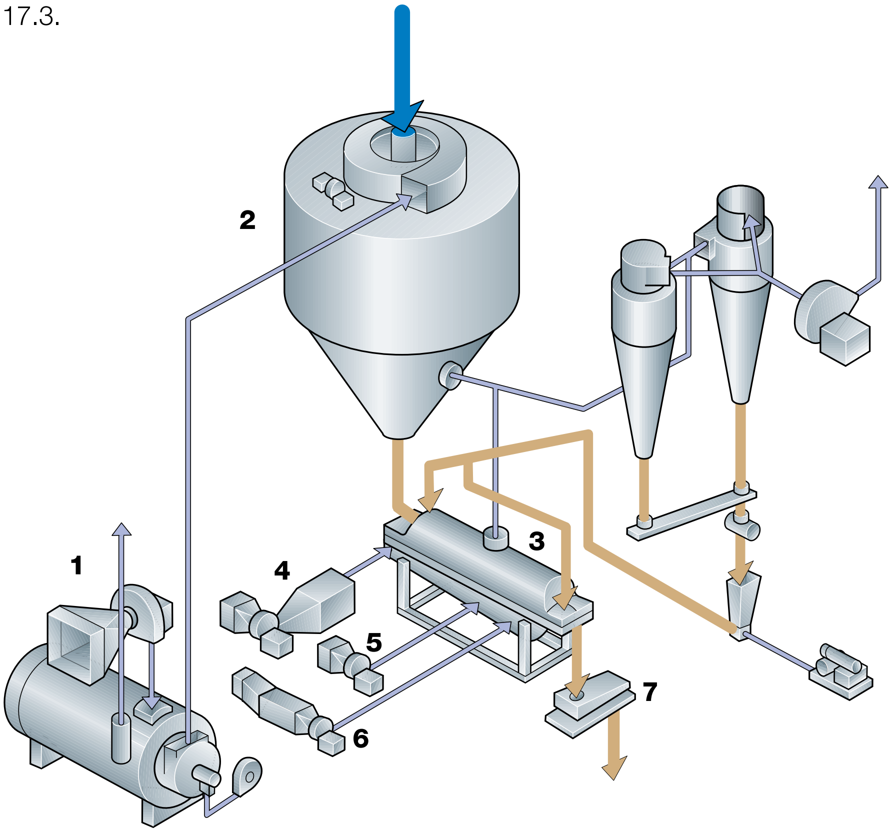


***Fig. 17.7** Spray dryer with fluid bed attachment (two-stage drying).*
1 Indirect heater
2 Drying chamber
3 Vibrating fluid bed
4 Heater for fluid bed air
5 Ambient cooling air for fluid bed
6 Dehumidified cooling air for fluid bed
7 Sieve

Three-stage drying

The three-stage dryer involves transfer of the second drying stage into the base of the spray drying chamber and having the final drying and cooling conducted in the third stage located outside the drying chamber.

There are two main types of three-stage dryers:

1 Spray dryers with integrated fluid bed
2 Spray dryers with integrated belt

The principle of the second type, spray dryers with integrated bed, will be touched upon below.

The Filtermat type of dryer is shown in figure 17.8. It consists of a main drying chamber (3) and three smaller chambers for crystallisation (when required, e.g. for production of whey powder), final drying and cooling (8,9, 10).

The product is atomised by nozzles located in the top of the main chamber of the dryer. The feed is conveyed to the nozzles by a high pressure pump. Atomisation pressure is up to 200 bar. Most of the drying air is supplied to the drying chamber around the individual nozzles at temperatures up to 280°C.

Primary drying of the droplets takes place as they fall from the nozzles (2) to the moving belt (7) located at the base of the chamber. The powder is deposited on the belt in an agglomerated porous layer.

The second drying stage takes place as drying air is sucked through the

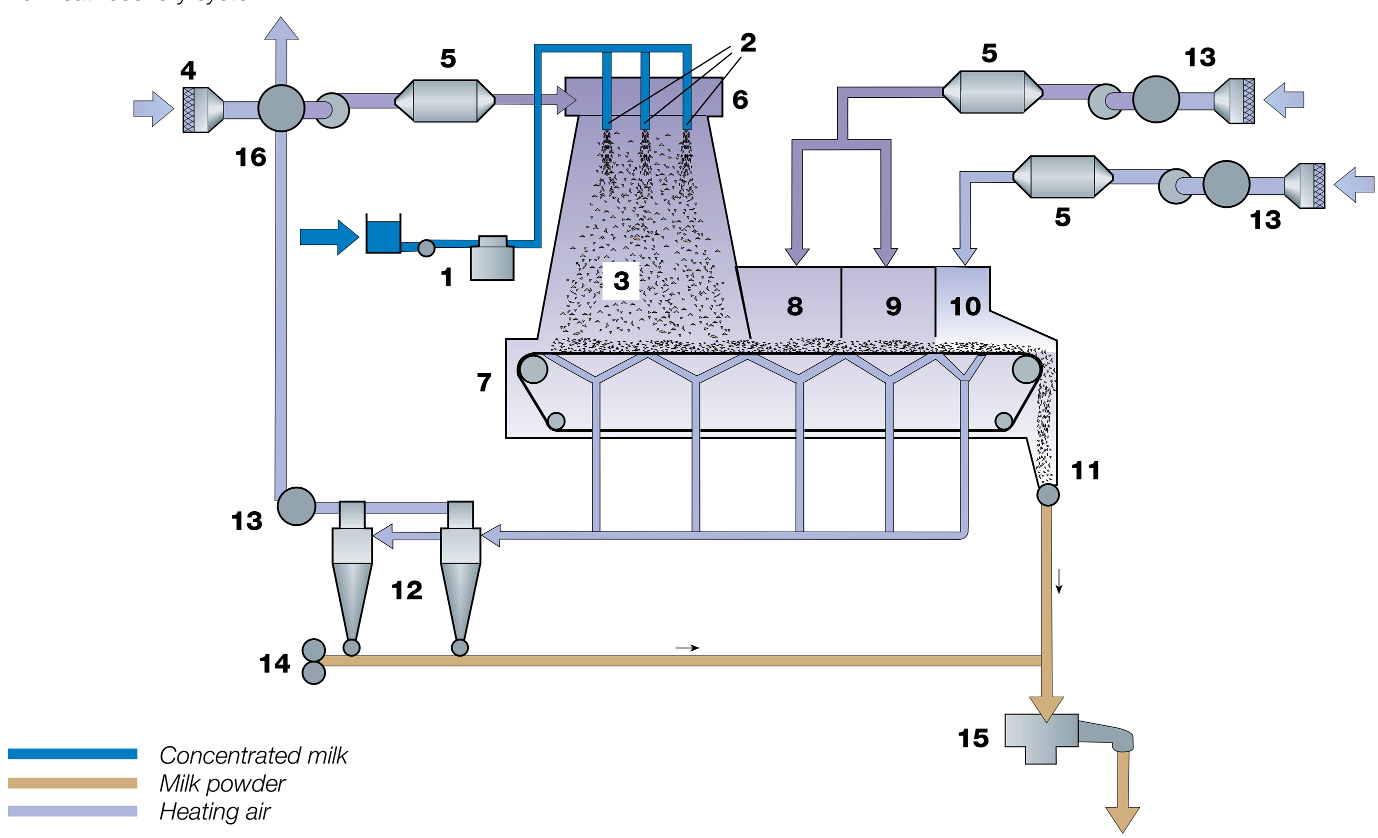
Table 17.3
Comparison of one-stage and two-stage drying systems.

Drying system	**One-stage Inlet temp. 200°C**	**Two-stage Inlet temp. 200°C**	**Inlet temp. 230°C**
Spray dryer (First stage)			
Evaporation in chamber, kg/h	1 150	1 400	1 720
Powder from chamber:			
6 % moisture, kg/h	–	1 460	1 790
3.5% moisture, kg/h	1 140	–	–
Energy consumption,			
spray drying total, Mcal	1 818	1 823	2 120
Energy/kg powder, kcal	1 595	1 250	1 184
Fluid Bed (Second Stage)			
Drying air, kg/h	–	3 430	4 290
Inlet air temperature, °C	–	100	100
Evaporation in fluid bed, kg/h	–	40	45
Powder from fluid bed			
3.5 % moisture, kg/h	–	1 420	1 745
Energy consumption, kW	–	20	22
Energy consumption,			
total in fluid bed, Mcal	–	95	115
Total plant			
Energy consump. total, Mcal	1 818	1 918	2 235
Energy/kg powder total, kcal	1 595	1 350	1 280
Energy relation	100	85	80

Basis: Same drying chamber size with inlet air flow = 31,500 kg/h.
Product: skimmilk, 48% solids in concentrate.

Source: Evaporation, Membrane Filtration, Spray Drying - North European Dairy Journal, 1985 Copenhagen, Denmark. ISBN No. 87-7477-000-4.

Fig. 17.8 *Spray dryer with integrated belt, Filtermat (three-stage drying).*
1 High pressure feed pump
2 Nozzle arrangement
3 Primary drying chamber
4 Air filters
5 Heater/cooler
6 Air distributor
7 Belt assembly
8 Retention chamber
9 Final drying chamber
10 Cooling chamber
11 Powder discharge
12 Cyclone arrangement
13 Fans
14 Fines recovery system
15 Sifting system
16 Heat recovery system



powder layer. The moisture content of the powder falling on the belt (7) is 12 – 20 % depending upon the type of product. This second drying stage on the belt reduces the moisture content to 8-10 %. The moisture content is very important to achieving the exact degree of agglomeration of the product and porosity of the powder layer. The third and last drying stage for skimmilk and whole milk concentrates takes place in two chambers (8, 9), where hot air at an inlet temperature of up to 130°C is sucked through the powder layer and the belt in the same way as in the main chamber. The powder is cooled in a final chamber (10). Chamber (8) is used in cases where crystallisation of lactose is required (whey powder). In this case air is not conveyed to the chamber, so the moisture content remains at a higher level, up to 10 %. The third drying stage takes place in chamber (9), and cooling air is supplied to chamber (10).

Only a small amount of powder leaves the plant together with the drying and cooling air as fines. This powder is separated from the air in a cyclone battery (12). The powder is recirculated, either to the main chamber or to a point in the process appropriate to the type of product and the agglomeration required.

After leaving the dryer the powder agglomerates are broken down to the required size in a sifter (15) or milled, depending on the type of product.

Production of instant powder

Milk powder which will dissolve quickly in water must be instantised, i.e. the milk particles must be treated so that they form larger, porous agglomerates. To obtain the correct porosity the milk particles must first be dried so that most of the water in the capillaries and pores is replaced by air. The particles must then be humidified, so that the surfaces of the particles swell quickly, closing the capillaries. The surfaces of the particles will then become sticky and the particles will adhere to form agglomerates.

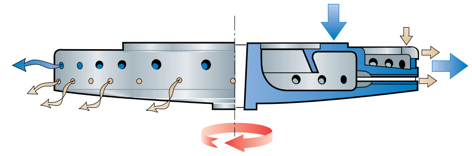


Fig. 17.9 *Rotating disc designed for production of instantised powder.*

One method of producing instantised powder is to recirculate the dry milk particles back to the mixing chamber containing drying air and atomised milk particles, figure 17.9. As soon as the dry particles are admitted to the chamber, their surfaces are humidified by the evaporated water and the particles swell. The capillaries and pores close and the particles become sticky. Other milk particles adhere to the surface and agglomerates are formed.

Fluid-bed drying

More efficient instantisation can be obtained with a fluid bed of the type shown in figure 17.10. The fluid bed is connected to the bottom of the drying chamber and consists of a casing with a perforated bottom. The casing is spring mounted and can be vibrated by a motor. When a layer of powder is distributed on the perforated bottom, the vibrations convey the powder at uniform speed along the length of the casing.

The powder from the drying chamber is admitted to the first section,

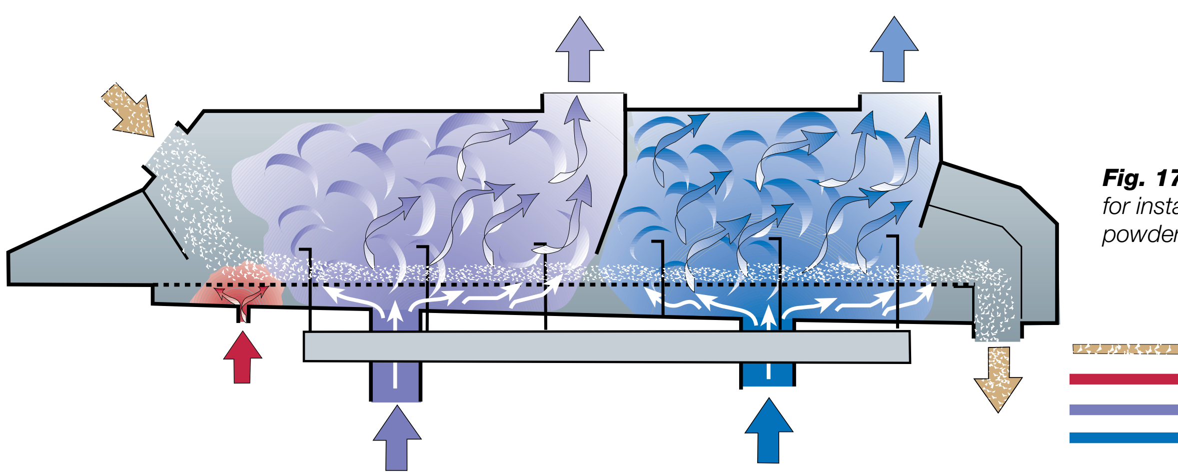


Fig. 17.10 *Fluid bed for instantising milk powder.*

where it is humidified by steam. The vibrations convey the powder through the drying sections, where air at a gradually decreasing temperature is admitted through the powder bed. Agglomeration takes place in the first stage of drying when the particles adhere to each other. Water is evaporated from the agglomerates during their passage through the drying sections. They will have attained the required dryness when they have passed through the fluid-bed casing.

Any larger particles at the outlet of the dry bed are screened and recirculated to the inlet. The screened and instantised particles are conveyed by the cooling air to a battery of cyclones, where they are separated from the air and packaged.

The drying air from the fluid bed, together with the air from the spray tower, is then blown to the cyclone for recovery of milk particles.

Heat recovery

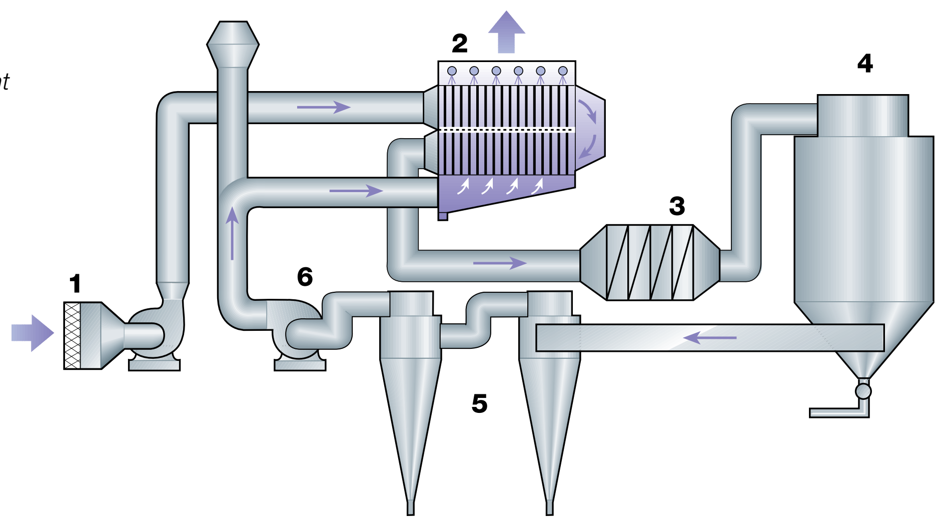
A large amount of heat is lost in the drying process. Some can be recovered in heat exchangers, but the drying air contains dust and vapour and therefore requires specially designed exchangers.

In several cases a special type of heat exchanger with glass pipes is used, see figure 17.11. The smooth glass surface prevents fouling to a great extent. A CIP system is included in the plant.

The warm air is introduced from the bottom and forced through the glass pipes. The fresh air to be heated flows on the outside of the pipes. With this method of heat recovery the efficiency of the spray drying plant can be increased by 25 – 30%.

A further possibility is to recover the heat in the condensate from the evaporation plant. The plant operates in parallel with the spray drying plant, and such a solution is therefore feasible with savings of 5—8% of the drying costs.

***Fig. 17.11** Heat recovery from effluent air in a spray drying plant.*
1 Fan for fresh air
2 Glass pipe heat exchanger
3 Heater
4 Spray tower
5 Cyclones
6 Fan for effluent air



Packing milk powder

The types and sizes of packages vary widely from one country to another. The powder is often packed in laminated powder bags with an inner bag of polyethylene. The polyethylene bag is often welded, and this package is practically as airtight as sheet-metal drums. The most common bag sizes are 25 and 15 kg, although other sizes are also used as it is very easy to vary the weight of the powder in the bags to meet specific customer requirements. Milk powder for households and similar small-scale consumers is packed in tin cans, laminated bags or plastic bags which, in turn, are packed in cartons.

Changes in milk powder during storage

The fat in whole milk powder oxidises during storage. On an industrial scale the shelf life can be extended by special pretreatment of the milk, by the addition of anti-oxidants and, in the case of sheet-metal drums, by filling under inert gas.

Milk powder should be stored under cool conditions and protected against contact with water during storage. All chemical reactions in milk powder, at room temperature and with a low water content, take place so slowly that the nutritive value is not affected even after years of storage.

Dissolving milk powder

One part of ordinary spray-dried powder is mixed with about ten parts of water at a temperature of 30 – 50°C. The dissolving time is about 20 – 30 minutes. Longer times are needed at lower temperatures. 8 – 12 hours are required if the powder is to be dissolved in cold water.

If instantised powder is used, the required quantity of water is poured into a tank and the powder is then added. The powder dissolves after very brief stirring, even if the water is cold. The milk is then immediately ready for drinking.

The water quality is very important at dissolving. It must be borne in mind that at drying including the first concentration phase (evaporation), the milk has been rid of pure (distilled) water. More about the water quality in chapter 18, Recombined milk products.