Chapter 16

Condensed milk

The method of preserving milk by sterilising evaporated milk in sealed containers was developed at the beginning of the 1880s. Earlier, in about 1850, the method of preserving evaporated milk by the addition of sugar had been perfected by an American. The manufacture of condensed milk, using these two methods, has developed into a large-scale industry.

A distinction is made between two different types; unsweetened (evaporated) and sweetened condensed milk.

Unsweetened condensed milk (also called double concentrated milk) is a sterilised product, light in colour and with the appearance of cream. The product has a large market, for example in tropical countries, at sea and for the armed forces. It is used where fresh milk is not available. Unsweetened

condensed milk is also used as a substitute for breast milk. In this case vitamin D is added. It is also used for cooking, as coffee cream, etc. The product is made from whole milk, skimmilk or recombined milk with skimmilk powder, anhydrous milk fat (AMF) and water as typical ingredients (see also chapter 18, Recombined milk products).

Outline of condensed milk

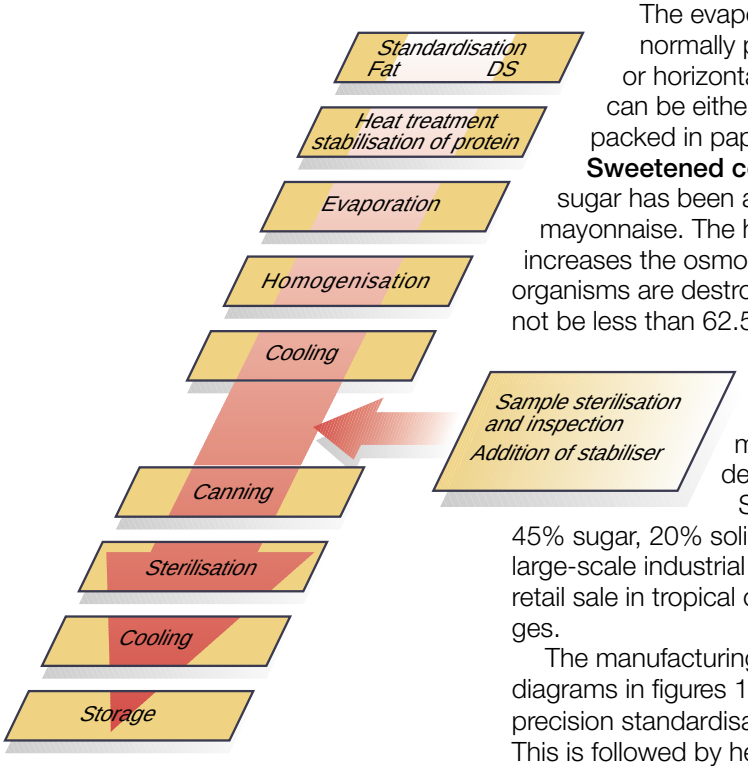

Fig. 16.1 *Process steps for unsweetened condensed milk.*

The evaporated product, the **unsweetened condensed milk**, is normally packed in cans which are then sterilised in autoclaves or horizontal sterilisers. Concentrates based on recombined milk can be either canned and sterilised in the cans or UHT-treated and packed in paperboard packages.

Sweetened condensed milk is basically concentrated milk to which sugar has been added. The product is yellowish in colour and looks like mayonnaise. The high sugar concentration in sweetened condensed milk increases the osmotic pressure to such a level that most of the microorganisms are destroyed. The sugar concentration in the water phase must not be less than 62.5% or more than 64.5%. At the latter level the sugar solution reaches its saturation point and some sugar will then crystallise, forming a sediment. Sweetened condensed milk can be made from whole milk or skimmilk, or from recombined milk based on skimmilk powder, anhydrous milk fat (AMF) and water.

Sweetened condensed whole milk contains 8% fat, 45% sugar, 20% solids-non-fat and 27% water. It is packed in barrels for large-scale industrial use (in ice-cream and chocolate factories), in cans for retail sale in tropical climates, and lately also in aseptic paperboard packages.

The manufacturing processes for the two products are shown as block diagrams in figures 16.1 and 16.2. The first stage in both cases comprises precision standardisation of the milk fat content and the dry matter content. This is followed by heat treatment, which serves partly to destroy the microorganisms in the milk and partly to stabilise the milk so that it will not coagulate in the subsequent sterilisation process. Raw material requirements and the initial treatment are identical for both products. After that the processes differ slightly.

In the manufacture of **unsweetened condensed milk** the heat-treated milk is pumped to an evaporator, where it is concentrated. The milk is then homogenised before cooling. Checks are carried out on the coagulation stability of the milk before it is packed and a stabiliser, usually disodium or trisodium phosphate, is added if necessary. The product is then packed in cans which are placed in an autoclave for sterilisation. The cans are cooled before being placed in storage.

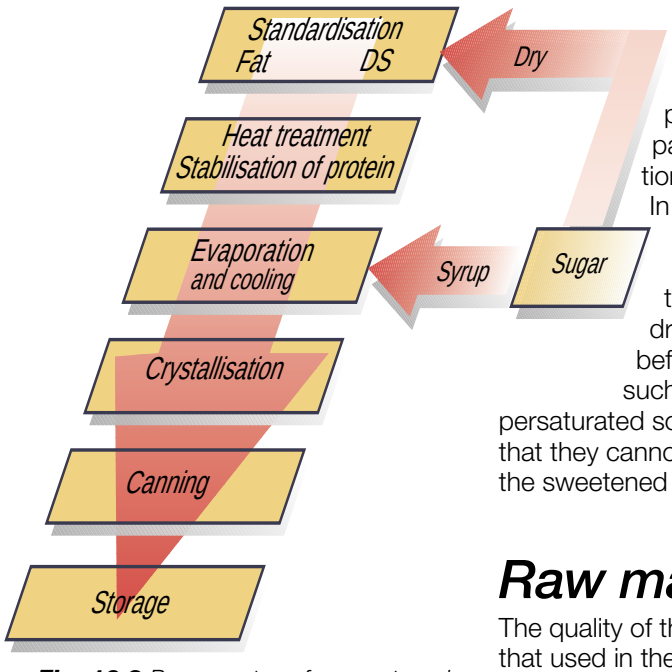

Fig. 16.2 *Process steps for sweetened condensed milk.*

In the manufacture of **sweetened condensed milk** the heat-treated milk is pumped to the evaporator, where it is concentrated. Sugar in solution is usually added to the concentrate during evaporation, but the sugar can also be added dry, in the correct proportion calculated on dry substance, before evaporation. After concentration the product is cooled in such a way that the lactose forms very small crystals in the supersaturated solution. These crystals must be so small, less than 10 µm, that they cannot be detected by the tongue. After cooling and crystallisation the sweetened condensed milk is canned and stored.

Raw material for condensed milk

The quality of the raw material for condensed milk is basically the same as that used in the manufacture of ordinary milk products. There are two other important considerations for the manufacture of condensed milk:

- The number of spores and heat resistant bacteria in milk
- The ability of the milk to tolerate intensive heat treatment without coagulating (protein stability).

Bacteriological quality of the raw material

Evaporation takes place under vacuum at a temperature which should not exceed 65 – 70°C. At temperatures below 65°C spores and heat-resistant bacteria will have ideal growth conditions, which could result in the entire process being spoiled. Precise control of the bacteria in the process is thus an essential requirement in the manufacture of condensed milk.

Thermal stability of the raw material

The ability of milk to withstand intensive heat treatment depends to a great extent on its acidity, which should be low, and on the salt balance in the milk. The latter is affected by seasonal variations, the nature of the fodder and the stage of lactation. It is possible to improve the ability of the milk to withstand the required level of heat treatment.

Pretreatment

Pretreatment is essentially the same for both unsweetened and sweetened condensed milk; it includes standardisation of fat content and solids-non-fat as well as heat treatment.

Standardisation

Condensed milk is marketed with a stipulated content of fat and dry solids. The figures vary with the applicable standard, but are normally 8% fat and 18% solids-non-fat. The ratio of fat to solids-non-fat is consequently 8:18 or 1:2.25. The stipulated percentages are minimum values which must be maintained, but for reasons of economy they should not be exceeded by more than a reasonable margin. Operating levels can be set accordingly, for example 8.05% fat and 18.10% solids-non-fat.

Modern automatic standardisation systems permit continuous and extremely accurate standardisation of both fat content and the relation between fat content and solids-non-fat of the basic milk. More information on standardisation will be found in chapter 6.2, Centrifugal machines and milk fat standardisation systems.

Heat treatment

Before being sterilised the standardised milk undergoes intensive heat treatment to destroy micro-organisms and to improve its coagulation stability. The heat treatment, often integrated in the evaporation plant, takes place in a shell-and-tube or plate heat exchanger at a temperature of 100 – 120°C for 1 – 3 minutes, followed by chilling to about 70°C before the milk enters the evaporator.

During heat treatment a great part of the whey proteins is denatured, while calcium salts are precipitated. In this way the protein complex of the milk is stabilised so that it can withstand subsequent sterilisation without coagulation taking place during storage.

The nature of the heat treatment will largely determine the viscosity of the end product, and is thus extremely important to the quality of the product.

Unsweetened condensed milk

Figure 16.3 shows the various stages in the manufacture of unsweetened condensed milk. The raw material is fresh milk.

Evaporation

The evaporator is usually of the multistage falling-film type. The milk passes through steam-heated tubes under vacuum. Boiling takes place at between 65 and 70°C. The dry matter content of the milk increases as the water is

1 *Evaporation*
2 *Homogenisation*
3 *Cooling*
4 *Intermediate tank*
5 *Canning*
6 *Sterilisation*
7 *Storage*
Alternative processing to point 5 and 6:
8 *UHT treatment*
9 *Aseptic filling*

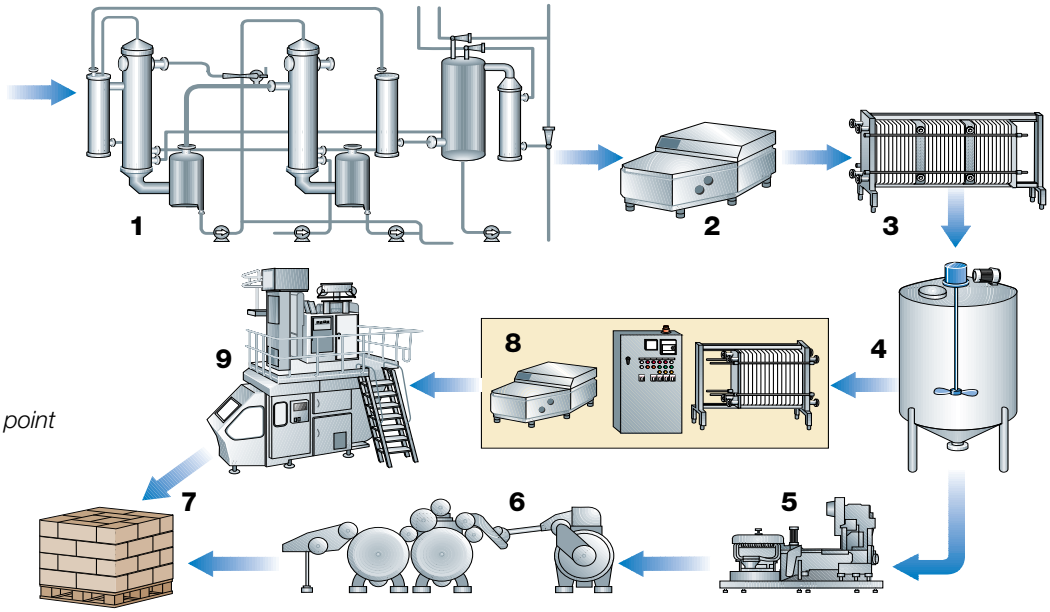

Fig. 16.3 *Process line for unsweetened condensed milk.*

boiled off. The density is checked continuously. The concentration of dry solids is correct when the density has reached a value of about 1.07. At this stage, 1 kg of unsweetened condensed milk with 8% fat and 18% solids-non-fat will have been produced from 2.1 kg of raw milk of a fat content of 3.8 % and a solids-non-fat content of 8.55 %.

Homogenisation

The concentrated milk is pumped from the evaporator to a homogeniser, which operates at a pressure of 12.5 – 25 MPa (125 – 250 bar). Homogenisation disperses the fat and prevents the fat globules from coalescing during subsequent sterilisation. Two-stage homogenisation is normally recommended.

Homogenisation should not be too intensive, because that might impair the stability of the protein with the consequent risk of the milk coagulating during sterilisation. It is therefore necessary to find the exact homogenisation pressure that is high enough to produce the required fat dispersion, yet low enough to eliminate the risk of coagulation.

Cooling and sample sterilisation

After homogenisation, the milk is cooled to about 14°C if it is to be packed immediately, or to between 5 and 8°C if it is to be held in storage to await sample sterilisation. A final check of the fat content and the solids-non-fat is usually made at this stage.

As mentioned previously, the heat stability of the condensed milk can be improved by the addition of a stabiliser, usually disodium or trisodium phosphate. The quantity of phosphate to be added is determined by sample sterilisation.

Any addition of vitamins is also done at this stage.

Canning

Canning machines for condensed milk automatically fill and seal the cans before sterilisation. The canning temperature is selected to give the lowest possible froth formation.

Sterilisation

The filled and sealed cans pass from the filling machine to the autoclave, which operates either continuously or on the batch principle. In the *batch autoclave* the cans are first stacked in special crates, which are then

stacked inside the autoclave. In the continuous autoclave, the cans pass through on a conveyor belt at a precisely controlled speed (see also figures in chapter 9, Long life milk).

In both types the cans are kept in motion during sterilisation to distribute the heat more quickly and more evenly through the cans. Any protein precipitated during heat treatment is uniformly distributed throughout the milk. After a certain period of heating the milk reaches the sterilisation temperature of 110 – 120°C. This temperature is maintained for 15 – 20 minutes, after which the milk is cooled to storage temperature.

The heat treatment is intense. This results in a light brown coloration because of chemical reactions between the protein and the lactose (Maillard reaction or browning reaction).

UHT treatment

UHT treatment plants (described in chapter 9, Long life milk), can also be used for high heat treatment of condensed milk. In this case, following sample sterilisation and addition of a stabiliser if required, the milk is pumped to the UHT plant, where it is heated to 140°C for about 3 seconds. After cooling, the milk is packed in aseptic paperboard packages and stored.

Storage and inspection

The cans and/or the aseptic paper board packages of condensed milk are labelled before being packed in cardboard cartons. Condensed milk can be stored for practically any length of time at a temperature of 0 – 15°C. The milk goes brownish if the storage temperature is too high, and protein will precipitate if the storage temperature is too low.

Condensed milk should be light in colour and have the appearance of cream. Several sample cans should be taken from each production batch for inspection. These cans are incubated at three different temperatures: ambient temperature, 30°C and 38°C. The cans are examined after 10 – 14 days to determine the quality of the batch. Condensed milk is tested for fat and solids-non-fat, viscosity and bacteria and spore counts, as well as for colour, odour and taste. A number of cans are kept for up to one year for complaint evaluation and similar purposes.

Sweetened condensed milk (SCM)

Figure 16.4 shows a process line for sweetened condensed milk manufactured from fresh milk. Before evaporation, the fat and solids-non-fat values of the milk have been standardised to predetermined levels in the same way as for unsweetened condensed milk. The milk has also been heat-treated to destroy micro-organisms and enzymes which could cause problems and to stabilise the protein complex. Heat treatment is important to the development of product viscosity during storage, and is particularly important in the case of sweetened condensed milk. A gel can form if the heat treatment is too severe. The milk is usually heat-treated at 82°C for 10 minutes if a product with a relatively high viscosity is required. If a low-viscosity product is required, the temperature/time combination should be 116°C/30 sec.

The addition of sugar is a key step in the manufacture of sweetened condensed milk. It is important that the correct proportion is added, as the shelf life of the milk depends on its osmotic pressure being sufficiently high. A sugar content of at least 62.5% in the aqueous phase is required to produce an osmotic pressure high enough to inhibit the growth of bacteria.

Two methods are used for addition of sugar:

- Addition of dry sugar before heat treatment
- Addition of sugar syrup in the evaporator.

The stage at which the sugar is added affects the viscosity of the end product. One theory maintains that early addition of sugar can cause the product to become too viscous during storage.

Stages in the manufacture of *sweetened* condensed milk:

- Addition of sugar and evaporation
- Cooling to about 30°C
- Seeding and subsequent cooling to 15 – 18°C (crystallisation)
- Canning (or packing) and inspection

1 *Evaporation*
2 *Homogenisation, if any*
3 *Cooling*
4 *Addition of lactose slurry*
5 *Crystallisation tank*
6 *Canning*
7 *Paperboard packaging alternative*
8 *Storage*

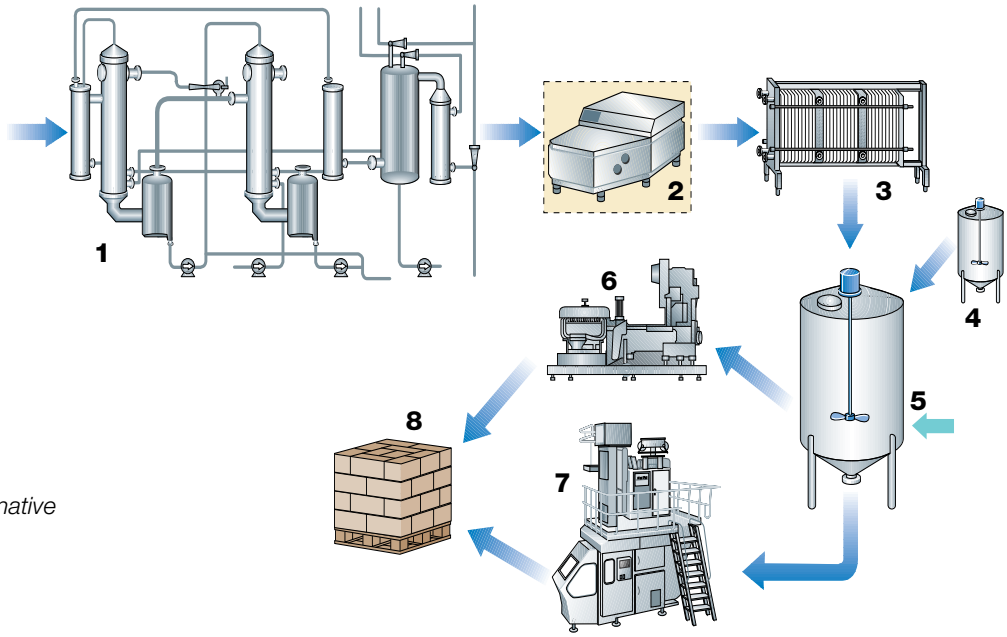

Fig. 16.4 *Process line for sweetened condensed milk.*

Evaporation

Evaporation of sweetened condensed milk is carried out in essentially the same way as for unsweetened. When sugar is added in the evaporator, the syrup is drawn into the evaporator and mixed with the milk at the half-way stage of the process. Evaporation then continues until the required dry matter content has been reached. The dry matter content is checked indirectly by determining the density of the concentrate. This should be about 1.30 for sweetened whole milk and about 1.35 for sweetened skimmilk when the correct dry matter value has been attained. At this stage 1 kg of sweetened condensed milk with 8% fat, 45% sugar and 27% water will have been produced from 2.5 kg of 3.2% full-cream milk mixed with 0.44 kg of sugar.

Some manufacturers homogenise the concentrate at 5 – 7.5 mPa (50 – 75 bar) immediately after evaporation as a measure to regulate the viscosity of the end product.

Cooling and crystallisation

Sweetened condensed milk must be cooled after evaporation. This is the most critical and important stage in the whole process. The water in the condensed milk can only hold half the quantity of lactose in solution. The remaining half will therefore be precipitated in the form of crystals. If the surplus lactose is allowed to precipitate freely, the sugar crystals will be large and the product will be gritty and unsuitable for many applications. It is consequently preferable to control the crystallisation of lactose so that very small crystals are obtained. The largest crystal size permitted in first-grade milk is 10 µm. These crystals will remain dispersed in the milk under normal storage temperatures, 15 – 25°C, and are not felt on the tongue.

The required crystallisation is accomplished by cooling the mixture rapidly under vigorous agitation, without air being entrapped. Seed crystals, in the form of finely ground lactose crystals, are added at a rate of about 0.05% of the total mix, either as powder or as a slurry, when the milk has cooled to crystallisation temperature (about 30°C). The mixture is cooled as quickly as possible to 15 – 18°C after continuous and vigorous agitation for about one hour.

The viscosity of sweetened condensed milk is high, which means that a very robust agitator is needed in the crystallisation tank.

The cooled condensed milk is pumped to a storage tank where it is kept until the following day to allow the crystallisation process to be completed.

Packing and inspection

Sweetened condensed milk should be yellowish in colour and have the appearance of mayonnaise. Traditionally, it is packed in cans, which in this case must be cleaned and sterilised before filling as no sterilisation takes place after canning.

Nowadays it is also possible to pack sweetened condensed milk in aseptic paperboard packages.

The product is also packed in beech-wood barrels, holding about 300 kg, for supply to large-scale users.

A number of sample cans or paperboard packages should be kept by the manufacturers of sweetened condensed milk, and the condition of the product should be monitored for up to one year. In addition to the analyses which are performed on unsweetened condensed milk, a check must be made on crystal size.