# BUTTER

Butter is generally made from cream by churning and working. It contains a good 80% fat, which is partly crystallized. The churning proceeds most easily at a temperature of around 15 to 20°C. Therefore, butter typically is a product originating from regions having a temperate climate. In addition to accumulated practical experience, a good deal of science has now been incorporated in butter making, enhancing the shelf life and quality of the product and the economy of manufacture.

Some *variants* occur: butter from cultured (soured) or from sweet cream and butter with or without added salt. Formerly, the salt was added as a preservative, but nowadays it is mainly added for the flavor; moreover, souring of the cream inevitably occurred (due to the duration of the gravity creaming), and now it is practiced intentionally. It enhances the keeping quality (although this hardly makes a difference when applying modern technology), and it greatly influences the flavor.

## Characteristic requirements and properties of Butter

1. *Flavor:* Off-flavors of the fat are to be avoided, especially those caused by lipolysis, but also those due to volatile contaminants. The latter mostly dissolve readily in fat; examples are off-flavors caused by feeds such as silage and *Allium* (onion) species. If the cream is heated too intensely, the butter gets a cooked flavor. Moreover, careful attention has to be paid to the souring (see the following text).
2. *Shelf life:* Spoilage by microorganisms may cause several off-flavors (putrid, volatile acid, yeasty, cheesy, and rancid). In cultured-cream butter, spoilage usually involves molds and yeasts, the pH of the moisture being too low (~4.6) for bacterial growth. Lipolysis causes a soapy-rancid flavor; no lipases formed by psychrotrophs should be present in the milk. Furthermore, autoxidation of the fat can occur, especially at prolonged storage, even at a low temperature (–20°C), leading to a fatty or even a fishy flavor.

3. *Consistency:* Butter derives its firmness largely from fat crystals that are aggregated into a network. Butter should be sufficiently firm to retain its shape; likewise, oiling off (that is, separation of liquid fat) should not occur. On the other hand, the butter should be sufficiently soft so as to be easily spreadable on bread. The consistency can cause problems, because the firmness and the spreadability depend strongly on the composition of the fat and on the temperature.
4. *Color and homogeneity:* These rarely pose problems.
5. *Yield:* Some fat is lost in the skim milk and in the buttermilk. If the water content is below the legal limit (for example, 16%), this also means a loss of yield.
6. *By-products:* Buttermilk is sometimes desirable, but often it is not, owing to insufficient demand. Sour-cream buttermilk is only applicable as a beverage (or as animal feed), but it keeps poorly due to rapid development of an oxidized flavor (Section 22.3). Sweet-cream buttermilk can more readily be incorporated in certain products.

**Butter Manufacturing**

The *skimming* is mainly done for economical reasons: (1) reduction of fat loss (e.g., the fat content of buttermilk is 0.4% and that of skim milk is 0.05%; this means that removal of 1 kg of skim milk from the liquid to be churned will result in an additional yield of about 4 g of butter), (2) reduction of the size of the machinery (especially the churn), and (3) reduction of the volume of buttermilk. Hence, a high fat content of the cream (e.g., 40%) has advantage, also because it counteracts development of off-flavors (see Subsection 18.3.3). If a continuous butter-making machine is used, the fat content of the cream is often taken even higher, for example, up to 50%.

*Pasteurization* serves to kill microorganisms, inactivate enzymes, make the cream a better substrate for the starter bacteria, and render the butter more resistant to oxidative deterioration (see Subsection 18.3.3). Overly intense heating causes a cooked or gassy flavor. Sometimes the cream is pasteurized in a vacreator, which involves the hot cream being put under vacuum to cool, due to which some compounds causing off-flavors are removed.

The *starter* (see Section 13.5) should produce lactic acid and 'aroma' (i.e., primarily diacetyl). Moreover, the starter should not be strongly reducing, because this causes loss of diacetyl (by reduction to acetoin and 2,3–butanediol). Aroma formation is extensively discussed in Subsections 13.1.2.2 to 13.1.2.4.

Use is made of a mesophilic mixed-strain starter culture, containing the acid producers *Lactococcus lactis* sspp. *lactis* and *cremoris*; and the aroma producers *Leuconostoc mesenteroides* ssp. *cremoris* and *Lactococcus lactis* ssp. *lactis* biovar. *diacetylactis*. The ratio between the numbers of acid and aroma producers is critical. If too few aroma producers are present, they will be overgrown by the others and little diacetyl would be formed. If the aroma bacteria predominate, too little lactic acid would be formed, and the pH would remain too high to produce sufficient diacetyl. Moreover, a careful selection of strains is needed, with respect to the reducing capacity of the starter, and the formation of acetaldehyde by the *diacetylactis* strains, because too much of it causes a yogurt-like flavor. The starter is usually cultured from a frozen concentrate. The inoculum percentage is high because the bacteria have to grow at a suboptimal temperature.

The purpose of *ripening* is to sour the cream and to crystallize fat. Without solid fat, churning is impossible, and too little solid fat goes along with excessive fat loss in the buttermilk. The method of cooling (temperature sequence) affects the butter consistency (see Subsection 18.3.2).

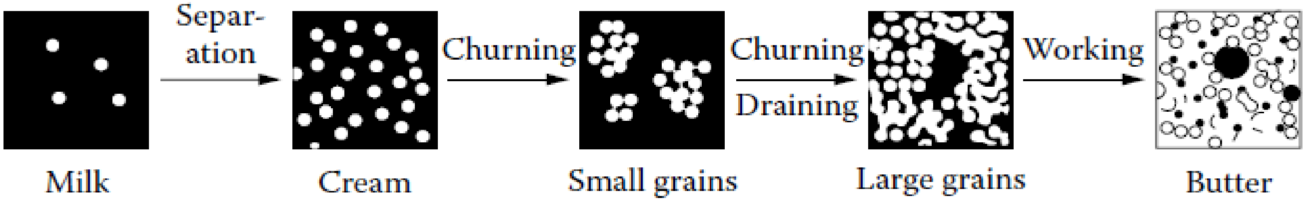
The *churning* is in most cases achieved by beating in of air (see Subsection 18.2.2). It can be done in a churn, mostly consisting of a large vessel (tub, cylinder, cube, or double-ended cone) with so-called dashboards, which is partly (at most half) filled with cream, and which is rotated at several revolutions per minute (r.p.m.). The churning then takes, say, 20 min. There are also churns with a rotary agitator (for example, 20 r.p.m.). The latter principle is also applied in the frequently used continuous butter-making machine according to Fritz (see Figure 18.3). Here the paddle turns very quickly (500 to 3000 r.p.m.) and the cream stays in it for less than 1 min. To achieve this, high-fat cream (about 50% fat) has to be used. These machines can have very large capacities.

The churning should proceed rapidly and completely (low fat content in the buttermilk), and the formed butter grains should have the correct firmness to allow for efficient working. The size of the butter grains can be varied by continuing the churning for various lengths of time after grains have formed. Very fine butter grains (on the order of 1 mm) are hard to separate from the buttermilk, especially in continuous machines.

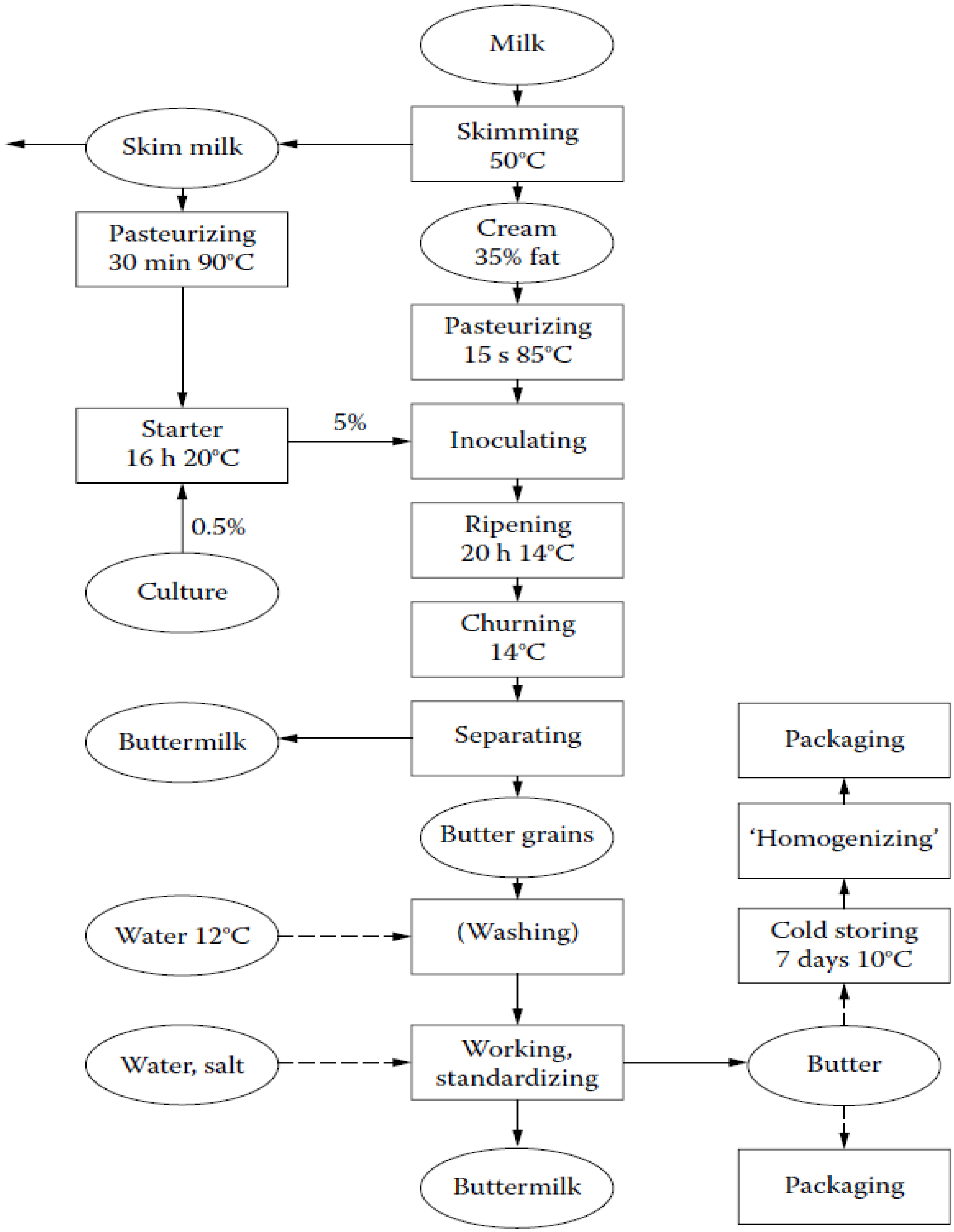
If the butter grains are not too large, their firmness can to some extent be affected by *washing*, that is, via the wash-water temperature. The washing consists of mixing the butter grains with cold water, after which the water again is drained off. This reduces the dry-matter content of the butter moisture. Formerly, washing was done to improve the keeping quality of the butter, but nowadays it is only done to control the temperature, if needed.

The *working* (kneading) is done (1) to transform the butter grains into a continuous mass; (2) to finely disperse the moisture in the butter; (3) to regulate the water content; and (4), if desired, to incorporate salt (see Subsection 18.2.3). Working consists of deforming the butter. This can, for instance, be achieved by squeezing the butter through rollers, by allowing it to fall from a height, or by squeezing the butter through perforated plates (in the continuous machines). During the working, the water content is regularly checked and, if need be, additional water is added to arrive at the accepted standard value.

The butter can now be immediately *packaged*, for example, in a retail package. Often one wants the butter after the working to be soft enough to be pumped from the churn-and-worker by a suitable positive pump. Sometimes, the butter is allowed to set (see Subsection 18.3.2), or it is for some other reason kept for some time before packaging. It is then too firm to pass through the packaging machine, and it must be passed through a butter 'homogenizer' to soften it; this may also prevent the moisture dispersion from becoming too coarse during packaging.




**Physical changes involved in butter manufacturing (Black is aqueous phase while white is fat)**




**Flow diagram of butter manufacturing process from ripened cream**