Chapter 12

Butter and dairy spreads

The International Dairy Federation, IDF, has introduced a standard concerning butters and spreads, viz. IDF Standard 166:1993, "Guidelines for Fat Spreads". These guidelines are intended to provide a broad framework permitting the development of more specific group or individual standards according to the requirements of individual countries.

Definitions

***Fat spread*:** A "fat spread" is a food in the form of an emulsion, which is mainly of the water-in-oil type, comprising principally an aqueous phase and edible fats and oils.
***Edible fats and oils*:** Foodstuffs mainly composed of triglycerides of fatty acids. They are of vegetable, animal, milk or marine origin.

The following tables (12.1 and 12.2) are excerpted from this standard.

Table 12.1
Essential composition of milk fat and margarine products

Milk fat products	Mixed fat products	Margarine products
Milk fat 100% of total fat	Milk fat min. 15%, max. 80% of total fat	Milk fat max. 3% of total fat

Note. A restricted zone (or zones) with respect to the fat content and to the proportion of milk fat to other types of fat may be imposed in accordance with national or other relevant legislation.

The principal raw materials should be water and/or milk products, edible fats and/or oils, or mixtures of these. Concerning the fat content, the standard states that fat spreads shall be classified into three groups according to the origin of the fat. The maximum fat content shall be 95%.

The name of the food shall be as specified in national legislation. The products, however, shall comply with the general requirements in table 12.2, which are designed to be applied consistently to products in all three groups.

Table 12.2
Names of milk fat and margarine products

Fat content %	Milk fat products	Mixed fat products	Margarine products
80 – 95	Butter*	Blend	Margarine*
>62 – <80	Dairy spread	Blended spread	Fat spread
60 – 62	3/4 fat or reduced fat butter	3/4 fat or reduced fat blend	3/4 fat or reduced fat margarine
>41 – <60	Reduced fat dairy spread	Reduced fat blended spread	Reduced fat spread
39 – 41	1/2 or low fat butter	1/2 or low fat blend	1/2 or low fat margarine or Minarine*
<39	Low fat dairy spread	Low fat blended spread	Low fat spread

* The following FAO/WHO individual standards currently apply to products in international trade and indicate the designations permitted:
A1 – Standard for Butter and Whey Butter
(A16 – Standard for Low Fat Dairy Spreads – draft)
Codex Standard 32–1981 for Margarine
Codex Standard 13–1981 for Minarine

Table 12.3
Examples of fat products (Sweden)

Product/ Composition	Butter	Margarine	Dairy Spread Bregott (Margarine)	Low fat Dairy spread Lätt & Lagom (Minarine)	M-cocos	Lard
Basic material	Cultured cream	Veg. oils and fats	Cultured cream and vegetable oil	AMF* + vegetable oil + conc. of butter milk pref.	Coconut oil	Lard
Fat, %	80	80	80	40	100	100
Moisture, %	16 – 18 **	≈18	17 – 18**	48	0	0
Salt, %	0 – 2	1.5 – 2.0	1.4 – 2.0	1.2	0	0
Protein, %	0.7	0.2 – 0.4	0.6	7.5	0	0
Specific energy kJ/100 g	3 140	3 100 – 3 150	3 140	1 710	3 900	3 900
Vitamins	A 2 500	A 3 000	A 3 000	A 3 000	0	0
I.U./100 g	D 55	D 300	D 300	D 300	0	0
Keeping quality at 6–7°C	2 – 3 months	3 months	2 – 3 months	1.5 months	6 – 12 months	6 months
Usage	Table Cooking	Table Cooking	Table Cooking	Table	Cooking Confectionery	Frying Baking

* AMF = Anhydrous Milk Fat
** Varies with salt content
Table from Livsmedelsbranschens Utbildningsorgan, Brevskolan, Sweden

Table 12.3, which lists the names, approved designations and compositions of some commercial fat products in Sweden, can serve as an example.

For many years there were just a few recognised types of cooking fat, viz. butter, margarine, lard and coconut oil.

Butter and margarine are the two products that most interest is focused on. Both products are used for spreading on bread as well as for cooking and baking. Both of them share the disadvantage that when traditionally produced, they do not spread easily at ordinary refrigeration temperature (+5°C). This led to the development during the sixties and seventies of a variety of more readily spreadable proprietary products including low-fat (40%) blends, also called *minarines*, and later reduced-fat (60%) products called *mellarines*.

Butter

Butter is usually divided into two main categories:

- sweet cream butter;
- cultured or sour cream butter made from bacteriologically soured cream.

Butter can also be classified according to salt content: unsalted, salted and extra salted.

Until well into the 19th century, butter was still made from cream that had been allowed to sour naturally. The cream was then skimmed from the top of the milk and poured into a wooden tub. Butter was made by hand in churns. The natural souring process is very sensitive, and infection by foreign micro-organisms often spoiled the result.

As knowledge of cooling increased, it became possible to skim the cream before it had gone sour, and make butter from the sweet cream. Buttermaking methods gradually improved, and so did the product quality and economic yield. It was eventually found that sweet cream could be soured by the addition of naturally soured milk or acid buttermilk. It then became possible to make ripened cream butter under more controlled conditions.

The invention of the separator (1878) meant that cream could be skimmed from milk quickly and efficiently. It was also the start of large-scale buttermaking. Contributions to the quality of the product and buttermaking economics were also made by the introduction of pasteurisation in the 1880s, the use of pure bacteria cultures in the 1890s and the introduction of the buttermaking machine at the turn of the century.

Today's commercial buttermaking is a product of knowledge and experience gained over the years about such matters as hygiene, bacterial acidification and temperature treatment, as well as the rapid technical development that has resulted in the advanced machines now used.

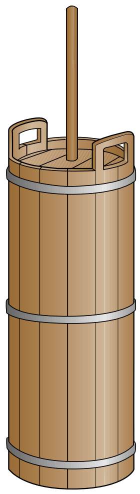

Fig. 12.1 *Traditional hand churn, formerly used for domestic buttermaking.*

Sweet and cultured (sour) cream butter

Variations in the composition of butter are due to differences in production.

As can be seen from table 12.3, butter contains 80% fat and 16 – 18 % moisture, basically depending on whether it is salted or not. Butter also naturally contains the vitamins A and D.

The colour of butter varies with the content of carotenoids, which make up from 11 to 50% of the total vitamin A activity of milk. As the carotenoid content of milk normally fluctuates between winter and summer, butter produced in the winter period has a brighter colour. (In this context it might be mentioned that butter made of cream from buffalo milk is white, as buffalo milk does not contain carotenoids.) Butter should also be dense and taste fresh. The water content should be dispersed in fine droplets so that the butter looks dry. The consistency should be smooth, so that the butter is easy to spread and melts readily in the mouth.

Sour cream butter should smell of diacetyl, while sweet butter should taste of cream – a faint "cooked" flavour is acceptable in the case of sweet butter.

Butter made from sour cream has certain advantages over the sweet cream variety. The aroma is richer, the butter yield higher, and there is less risk of reinfection after temperature treatment as the bacteria culture suppresses undesirable micro-organisms.

Sour cream butter also has its drawbacks. The buttermilk will also be acidified. Buttermilk from sour cream butter has a far lower pH than buttermilk from sweet cream butter, which sometimes makes it harder to dispose of than sweet buttermilk. Another disadvantage of cultured cream butter is that it is more sensitive to oxidation defects, which give it a metallic taste. This tendency is accentuated if the slightest trace of copper or other heavy metals is present, and this reduces the chemical keeping properties of the butter considerably.

Buttermaking

Butter can be produced in churns in a batch process or in a continuous process with modern buttermaking machines.

Butter was originally made on the farm for household use. Then a manually operated butter churn, as shown in figure 12.1, was used. Following churning and discharge of buttermilk, the butter grains were collected in a shallow trough and manually worked until acceptable dryness and structure were achieved.

Large-scale butter manufacturing processes generally involve quite a number of stages. Figure 12.2 schematically shows both batch production in a churn and continuous production in a buttermaking machine. Churns are still used, but are rapidly being replaced by continuous buttermaking machines.

The cream can be supplied by a liquid milk dairy (surplus cream) or separated from whole milk at the creamery. In the former case, the cream should have been pasteurised by the supplier. Storage and delivery to the creamery should be undertaken in such a way that reinfection, aeration or foaming do

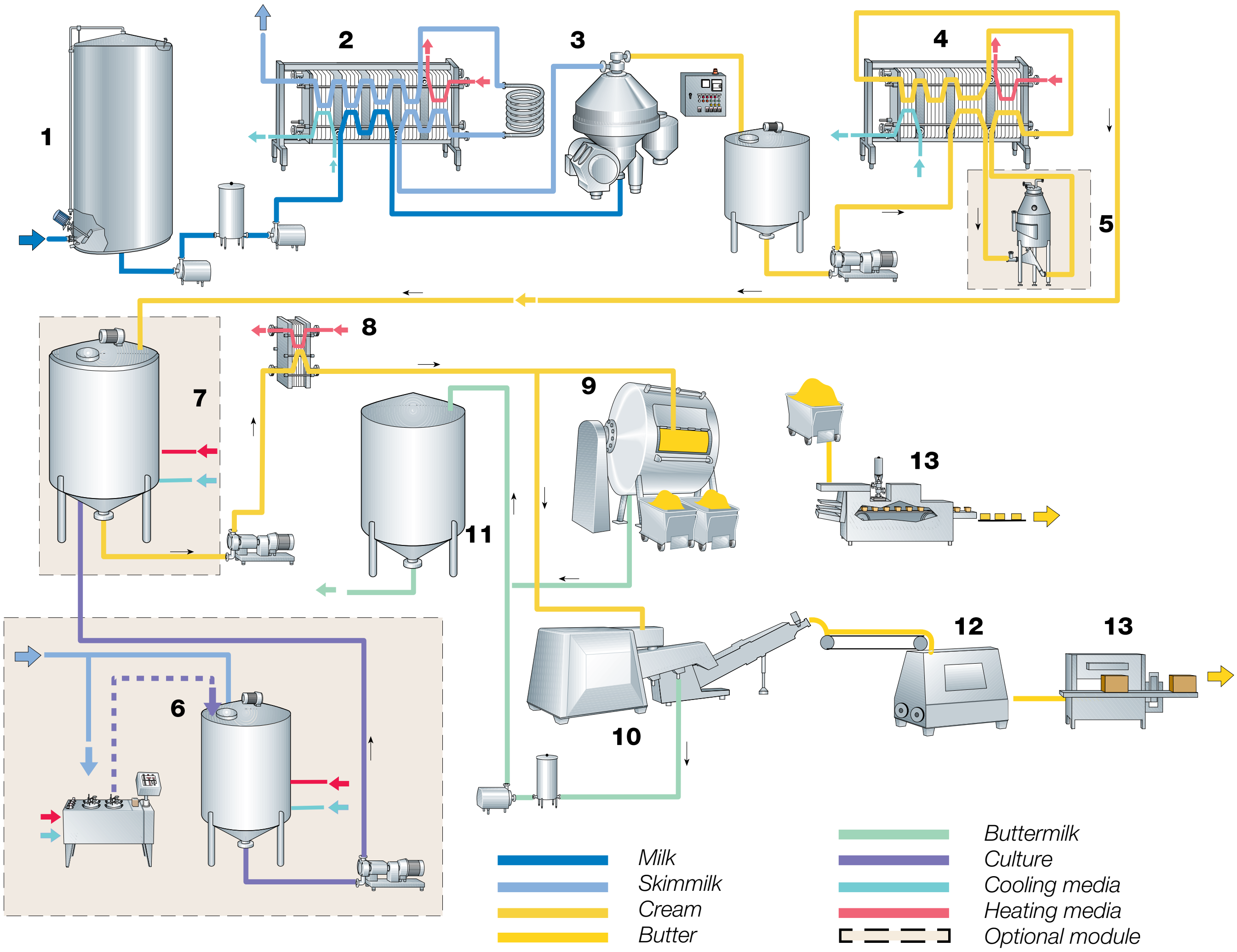

Fig. 12.2 General process steps in batch and continuous production of cultured butter

1 Milk reception
2 Preheating and pasteurisation of skimmilk
3 Fat separation
4 Cream pasteurisation
5 Vacuum deaeration, when used
6 Culture preparation, when used
7 Cream ripening and souring, when used
8 Temperature treatment
9 Churning/working, batch
10 Churning/working, continuous
11 Buttermilk collection
12 Butter silo with screw conveyor
13 Packaging machines

not take place. After reception procedures, weighing-in and analysis, the cream is stored in tanks.

If the cream is produced at the creamery, the whole milk is preheated to 63°C in the pasteuriser before being separated. The warm cream is routed into an intermediate storage tank before being pumped to the cream pasteurisation plant. For gentle treatment of the cream, please see the description of the *Scania method* in chapter 8.

The skimmilk from the separator is pasteurised and cooled before being pumped to storage. When cultured butter is to be produced, part of the skimmilk should be utilised for starter preparation.

From the intermediate storage tank(s) the cream continues to pasteurisation at a temperature of 95°C or higher. The high temperature is needed to destroy enzymes and micro-organisms that would impair the keeping quality of the butter.

The destruction of unwanted micro-organisms is also beneficial in the case of sour cream butter, as this creates perfect growth conditions for the bacteria culture. The heat treatment releases strongly antioxygenic sulphhydryl compounds, which further reduce the risk of oxidation.

Vacuum de-aeration can also be included in the line if the cream has an undesirable flavour or aroma, e.g. onion taste. Any flavouring will be bound in the fat and transmitted to the butter unless removed. Vacuum treatment before pasteurisation involves preheating the cream to the required temperature and then subjecting it to flash cooling to free any entrapped gas and volatile substances. After this the cream is returned to the pasteuriser for further treatment – heating, holding and cooling – before proceeding to the ripening tank.

In the ripening tank, of a recommended maximum volume of 30 000 l,

Vacuum deaeration is recommended when the cream has a very strong flavour or aroma defect, e.g. onion taste. Vacuum treatment may have an unfavourable effect on the yield and the butter consistency.

the cream is subjected to a temperature programme which will give the fat the required crystalline structure when it solidifies during cooling. The programme is selected to match factors such as the composition of the butterfat, expressed for example in terms of iodine value, which is a measure of the unsaturated fat content. The treatment can also be modified to produce butter with good consistency despite a low iodine value, e.g. when the unsaturated proportion of the fat is low.

Ripening usually takes 12 – 15 hours. Where possible, the acid-producing bacteria culture is added before the temperature treatment. The quantity of culture added depends on the treatment programme selected with reference to the iodine value, see table 12.4.

From the ripening tank the cream is pumped to the continuous buttermaker or the churn; sometimes a passage through a plate heat exchanger is desirable to bring it to the required temperature. In the churning process the cream is agitated violently to break down the fat globules, causing the fat to coalesce into butter grains. The fat content of the remaining liquid, the buttermilk, decreases.

The cream is split into two fractions: butter grains and buttermilk. In traditional churning the machine is stopped when the grains have reached a certain size, and then the buttermilk is drained off. Buttermilk drainage is continuous in continuous buttermaking machines.

After drainage the butter is worked to a continuous fat phase containing a finely dispersed water phase. It used to be common practice to wash the butter with water after churning to remove any residual buttermilk and milk solids, but this is rarely done nowadays. If the butter is to be salted, salt is spread over the surface in batch production, or added in slurry form during the working stage in continuous buttermaking.

After salting, the butter must be worked further to ensure uniform distribution of the salt. The working of the butter also affects the characteristics by which the product is judged – aroma, taste, keeping quality, appearance and colour. The finished butter is discharged into the packaging unit and thence to cold storage.

The raw material

The cream must be of good bacteriological quality, without taste or aroma defects. The iodine value is the deciding factor in the selection of manufacturing parameters. Unless corrected, fat with a high iodine value (high unsaturated fat content) will produce greasy butter. Butter of acceptable consistency can be obtained from both hard fat (iodine value down to 28) and soft fat (iodine value up to 42) by varying the ripening treatment to suit the iodine value.

Cream containing antibiotics or disinfectants is unsuitable for the manufacture of acidified butter. If harmful micro-organisms have been given the chance to develop, the cream cannot be used, even if they can be rendered inactive by heat treatment. Strict hygiene is therefore essential in all stages of the production process.

A problem in countries with a refrigerated distribution chain for raw milk is that cold storage causes changes in the micro-organic composition. Where lactic-acid bacteria once dominated there are now bacteria strains that have a high resistance to cold – the *psychrotrophic bacteria*. These are normally destroyed during pasteurisation and therefore have no effect on the quality of the butter. Some psychrotrophic bacteria strains, however, produce lipolytic enzymes which can break down the fat. They can withstand temperatures above 100°C. It is consequently vital that development of psychrotrophic bacteria is prevented. One solution is to chill the raw material to 2 – 4°C immediately on arrival at the dairy and store it at that temperature until it is pasteurised or, even better, to thermise the milk at 63 – 65°C for 15 seconds and cool it to 2 – 4°C. Pasteurisation should take place as soon as possible, and definitely not later than 24 hours after arrival.

Cream containing antibiotics or disinfectants is unsuitable for cultured butter manufacture.

Pasteurisation

Cream is pasteurised at a high temperature, usually 95°C or higher, normally without any holding time. The heat treatment should be sufficient to result in a negative peroxidase test.

This vigorous treatment kills not only pathogenic bacteria but also other bacteria and enzymes that could affect keeping quality. The heat treatment should not be so intense that there will be defects, such as a cooked flavour.

Vacuum deaeration

If necessary, any undesirable flavouring substances of a volatile nature can be removed by vacuum treatment. The cream is first heated to 78°C and then pumped to a vacuum chamber where the pressure corresponds to a boiling temperature of 62°C. The reduced pressure causes volatile flavouring and aromatic matter to escape in the form of gas when the cream is flash-cooled. After this treatment the cream is returned to the heat exchanger for pasteurisation and cooling, and then continues to the ripening tank.

Onion off-flavour is a very common defect during the summer, when various onion plants grow in the fields. Sorting of the cream is sometimes necessary to avoid strong flavours.

Heat treatment should be strong enough to result in a negative peroxidase test, but not so intense as to cause defects such as cooked flavour

Bacterial souring

Culture preparation

Bacteria cultures for the manufacture of cultured or sour cream butter are produced as described in chapter 10, "Cultures and starter manufacture". The addition of acid-producing bacteria gives the butter a strong aroma. It also improves the fat yield.

Starter cultures are of the LD or L type, which means that they contain the aroma-producing bacteria *Str. diacetylactis* (*Cit*+ *Lactococci*) and *Leuc. citrovorum* (*Leuconostoc mesenteroides ssp. cremoris*), or only the latter type.

In LD cultures the proportion of *Str. diacetiylactis* can vary between 0.6 and 13%, while the *Leuc. citrovorum* content varies from 0.3 to 5.9% of the total bacteria count. The proportional relationship between the aroma producers is governed by prevalent growth conditions.

Lactic acid, diacetyl and acetic acid are the most important of the aroma substances produced by bacteria. Production of the most important of the aromatics in butter, diacetyl, depends on the availability of oxygen.

The cultures must be active so that bacteria growth and acid production are rapid. A high bacteria count is then obtained (about 1 000 million bacteria per ml of mature culture). A 1% inoculum dosage and a growth temperature of 20°C should produce an acidity of 12°SH after 7 hours and 18 – 20°SH after 10 hours. The culture must be balanced. It is important that acid and aroma production and the subsequent reduction of diacetyl have the correct proportional relationship.

Skimmilk is mostly used as a substrate, or growth medium, for starter cultures, as it is easier to detect taste defects in skimmilk cultures. The milk should be pasteurised at 90 – 95°C for 15 – 30 minutes. The development of the acid and aroma forming process in an LD culture is shown in figure 12.3.

Slow acid production is characteristic of the first stage of growth. During this phase citric acid fermentation and diacetyl yield are relatively insignificant.

Acid production accelerates rapidly in the next phase as fermentation of citric acid forms diacetyl. Most of the diacetyl is reduced by the aroma-imparting bacteria.

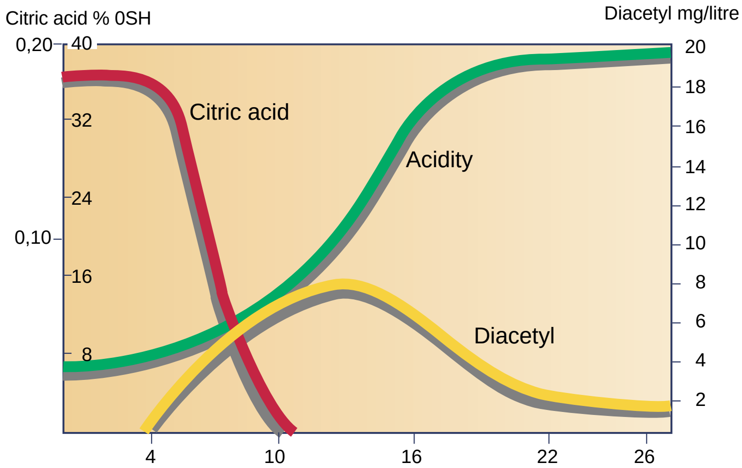

Fig. 12.3. *Acid and aroma development in skimmilk at 20°C and an LD culture dosage of 1%.*

\+ *Abbreviation for citrate, which is metabolised to flavour and aroma compounds.*

ssp = species of (New names for starters – see also Table 10.1 in Chapter 10)

When acid production has slowed down, reduction of diacetyl decreases and the content more or less stabilises. The culture enters the ripening phase when the acidification phase ends. Characteristics of this phase include a very gradual increase in acidity and a reduction of diacetyl to tasteless matter by the aroma bacteria.

Souring of the cream

The souring of the cream and the temperature treatment which gives the fat the necessary crystalline structure for optimum butter consistency take place simultaneously in the ripening tanks. These are usually triple-shell insulated tanks of stainless steel with the heating and cooling media circulating between the shells. They are fitted with reversible scraper agitators for efficient stirring, even when the cream has coagulated. Both heating and cooling are very gradual,with a smooth temperature characteristic which is advantageous from a consistency point of view.

The amount of bulk starter culture added to the cream varies from 1% to 7% basically depending on the incubation temperature.

The bulk starter should be well mixed before being pumped to the ripening tank. The starter is often pumped in before the cream. Some manufacturers, however, prefer to add the starter in the cream pipeline. Either way, the bulk starter must be carefully mixed into the cream.

The cream needs temperature treatment if the butter is to have the required consistency. The treatment programme depends on the iodine value of the cream. The acidification temperature will also be determined by this programme, as ripening takes place at the same time. It is possible to modify the consistency-related temperature programme so that it is adapted to the starter culture.

The amount of bulk starter to be added to the cream must be decided on the basis of the temperature programme for the process as shown in table 12.4. It must be proportioned to suit the acidifying and ripening temperatures as well as the duration of the various phases. Bulk starter dosage can vary from 1 to 7% of the amount of cream. The lower percentage applies to the temperature of 21°C at which cream with hard fat (low iodine value) is intermediately held; the higher percentage to cream with soft fat which is held at a temperature of 15 – 16°C. The souring process should be completed when the temperature treatment is finished and the cream proceeds to churning. The acidity of the non-fat part of the cream should then be about 36°SH.

Temperature treatment

Before churning, the cream is subjected to a programme of temperature treatment which will control the crystallisation of the fat so that the butter will have the desired consistency. The consistency of the butter is one of its most important quality characteristics, both directly and indirectly, as it affects the other characteristics – mainly taste and aroma. Consistency is a complicated concept involving properties such as hardness, viscosity, plasticity and spreadability.

The fatty acids in milk fat were described in chapter 2, The chemistry of milk. The relative amounts of fatty acids with high melting points determine whether the fat will be hard or soft. Soft fat has a high content of low-melting fatty acids, and at room temperature this fat has a large continuous phase of liquid fat, i.e. the ratio of liquid to solid fat is high. On the other hand, in a hard fat the ratio of liquid to solid fat is low.

In buttermaking, if the cream is always subjected to the same temperature treatment, it will be the chemical composition of the milk fat that determines the consistency of the butter. Soft milk fat will result in soft and greasy butter, whereas butter from hard milk fat will be hard and stiff. The consistency of the butter can be optimised if the temperature treatment is modified to suit the iodine value of the fat. The temperature treatment regulates the amount of solid fat to a certain extent – this is the major factor that determines the consistency of the butter.

Butterfat crystallisation

The fat in the fat globules is in liquid form after pasteurisation. When the cream is cooled to below 40°C the fat starts to crystallise. If the cooling is gradual, the different fats will crystallise at different temperatures, depending on their melting points. This would be an advantage, as this type of cooling would result in a minimum of solid fat – a soft butter could then be made from cream containing hard milk fat with low iodine values. The course of crystallisation in 40% cream is discussed in chapter 8 under the heading Production of cream.

Crystal formation is very slow during gradual cooling, and the crystallisation process takes several days. This would be dangerous from a bacteriological point of view, as the fat would be kept at temperatures sensitive to bacterial attack. It would also be impractical for economic reasons.

A method of speeding up the crystallisation process is quick cooling of the cream to a low temperature, where the formation of crystals is very rapid. The drawback of this method is that triglycerides with low melting points are "trapped" in the same crystals and mixed crystals are formed. A great proportion of the fat would be crystallised if no measures were taken. The ratio of liquid to solid fat would be low and the butter made from this cream would be hard.

Quick cooling of the cream to a low temperature speeds up the crystallisation process.

This can be avoided if the cream is heated carefully to a higher temperature to melt the low-melting triglycerides out of the crystals. The melted fat is then recrystallised at a slightly lower temperature, resulting in a higher proportion of "pure" crystals and a lower proportion of mixed crystals. A higher liquid-to-solids ratio and a softer fat will consequently be obtained.

It is obvious that the amount of mixed crystals, and thereby the ratio of liquid to solid fat, can be determined to a certain degree by selecting the heating temperature at which the fat crystals are melted after cooling and crystallisation and also the recrystallisation temperature. The temperatures are selected according to the hardness (iodine value) of the fat.

Several methods are now available for measuring the ratio of liquid to solid fat in a sample. The NMR pulse spectrometer test is a very fast and accurate method. This technique is based on the fact that protons (hydrogen nuclei) in fat have different magnetic properties according to whether the fat is in the liquid or solid state.

Table 12.4 gives examples of programmes for different iodine values. The first temperature is the value to which the cream is cooled after pasteurisation, the second the heating/souring value and the third the ripening value.

Treatment of hard fat

For optimum consistency when the iodine value is low, i.e. the butterfat is hard, the amount of mixed crystals must be minimised and the amount of "pure" fat maximised to increase the ratio of liquid to solid fat in the cream. The liquid-fat phase in the fat globules will then be maximised and much of it can be pressed out during churning and working, resulting in butter with a relatively large continuous phase of liquid fat and with a minimised solid phase.

The treatment necessary to achieve this result comprises:

- Rapid cooling to about 8°C and storage for about 2 hours at that temperature.
- Gentle heating to 20 – 21°C and storage at that temperature for at least 2 hours. Water at max. 27°C is used for heating.
- Cooling to about 16°C and then to churning temperature.

Cooling to about 8°C starts the formation of mixed crystals that bind fat from the liquid continuous phase.

When cream is heated gently to 20 – 21°C, the bulk of the mixed crystals melt, leaving only pure crystals of fat with a high melting point. During the storage period at 20 – 21°C the melted fat crystals begin to recrystallise, now forming pure crystals.

After 1 – 2 hours the higher-melting fat has started to recrystallise. When the temperature is reduced to about 16°C, the melted fat continues to crystallise and form pure crystals. During the holding period at 16°C all fat with a melting point of 16°C or higher will crystallise. The treatment has caused the high-melting fat to form pure crystals and thereby reduced the amount

Table 12.4.
Principal temperature programmes adjusted to the iodine value and recommended volumes of culture, when used.

Iodine value	Temperature programme, °C	Approx % of starter in cream
<28	8 – 21 – 20	1
28 – 29	8 – 21 – 16	2 – 3
30 – 31	8 – 20 – 13	5
32 – 24	6 – 19 – 12	5
35 – 37	6 – 17 – 11	6
38 – 39	6 – 15 – 10	7
>40	20 – 8 – 11	5

of mixed crystals. This increases the ratio of liquid to solid fat, and the butter made from the cream will consequently be softer.

Treatment of medium-hard fat

With an increase in the iodine value the gentle heating is stopped at a lower temperature. A greater amount of mixed crystals will form, absorbing more liquid fat than is the case in the hard-fat programme. For iodine values up to 39, the heating temperature can be as low as 15°C.

The souring time is extended at the lower temperatures.

Treatment of very soft fat

The "summer method" of treatment is used when the iodine value is higher than 39 – 40. After pasteurisation the cream is cooled to 20°C and soured for about 5 hours at that temperature. It is cooled when the acidity is about 22°SH. The cream is cooled to about 8°C if the iodine value is around 39 – 40, and to 6°C if it is 41 or higher. It is generally believed that souring temperatures below 20°C will result in soft butter. The same applies to higher cooling temperatures after souring.

Churning

Batch production

The cream is churned after temperature treatment and after souring where applicable. Butter is traditionally made in cylindrical, conical, cubical or tetrahedral churns with adjustable speed. Axial strips and dashers are fitted inside the churn. The shape, setting and size of the dashers in relation to the speed of the churn are factors that have an important effect on the end product. Modern churns have a speed range that permits selection of the most suitable working speed for any set of butter parameters.

The size of churns has increased greatly in recent years. Churns of 8 000 – 12 000 litres' capacity or more are used in large central creameries.

Before transfer to the churn the cream is stirred and the temperature adjusted. The churn is usually filled to 40 – 50% to allow space for foaming.

Butter formation

The fat globules in cream contain both crystallised fat and liquid fat (butter oil). The fat crystals have to some extent become structured so that they form a shell, although a weak one, closest to the membrane of the fat globule.

A foam of large protein bubbles forms when the cream is agitated. Being surface active, the membranes of the fat globules are drawn towards the air/water interface and the fat globules are concentrated in the foam.

When agitation continues, the bubbles become smaller as the protein gives off water, making the foam more compact and thereby applying pressure on the fat globules. This causes a certain proportion of the liquid fat to be pressed out of the fat globules and some of the membranes to disintegrate.

The liquid fat, which also contains fat crystals, spreads out in a thin layer on the surface of the bubbles and on the fat globules. As the bubbles become increasingly dense, more liquid fat is pressed out and the foam is soon so unstable that it collapses. The fat globules coagulate into grains of butter. At first these are invisible to the naked eye, but they grow progressively larger as working continues.

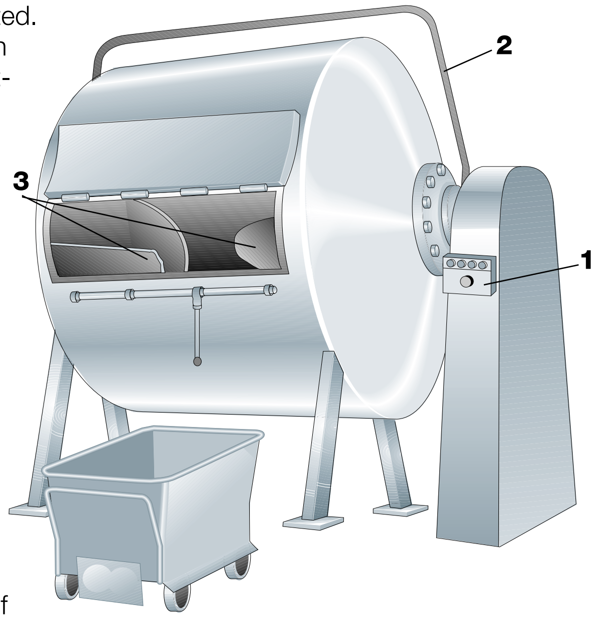

Fig. 12.4 Butter churn for batch production.

1 Control panel
2 Emergency stop
3 Angled baffles

Churning recovery

Churning recovery (yield) is a measure of how much of the fat in the cream has been converted to butter. It is expressed in terms of the fat remaining in the buttermilk as a percentage of the total fat in the cream. For example, a churning recovery of 0.50 means that 0.5% of the cream fat has remained in the buttermilk and that 99.5% has been turned into butter. Churning yield is considered acceptable if the value is less than 0.70.

The curve in fig. 12.5 shows how churning recovery can vary over the year. The fat content of buttermilk is highest during the summer.

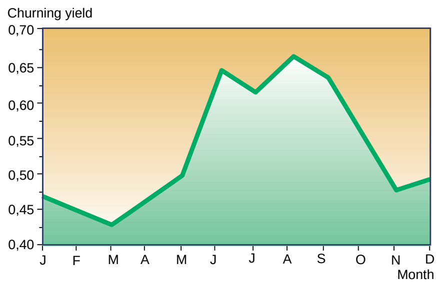

Fig. 12.5 How churning yield can vary during the year (Sweden)

Working

Working takes place when the buttermilk has been drained off. The butter grains are pressed and squeezed to remove the moisture between them. The fat globules are subjected to a high pressure and liquid fat and fat crystals are forced out. In the resulting mass of fat (eventually the continuous phase) the moisture becomes finely dispersed by the working process, which is continued until the required moisture content is obtained. The finished butter should be dry, i.e. the water phase must be very finely dispersed. No water droplets should be visible to the naked eye.

The moisture content should be checked regularly during working and adjusted so that it complies with the requirements for the finished butter.

Vacuum working

Working at reduced air pressure is a method that is frequently used. The result is a butter that contains less air and it is therefore somewhat harder than normal. In vacuum-worked butter the air amounts to about 1% by volume as compared with 5 – 7% for normal butter.

Continuous production

Methods of continuous buttermaking were introduced at the end of the 19th century, but their application was very restricted. Work was resumed in the 1940s and resulted in three different processes, all based on the traditional methods: churning, centrifugation and concentration or emulsifying. One of the processes, based on conventional churning, was the Fritz method. This now predominates in Western Europe. In machines based on this method, butter is made in more or less the same way as by traditional methods. The butter is basically the same, except that it is somewhat matt and denser as a result of uniform and fine water dispersion.

The manufacturing process

The cream is prepared in the same way as for conventional churning before being continuously fed from the ripening tanks to the buttermaker.

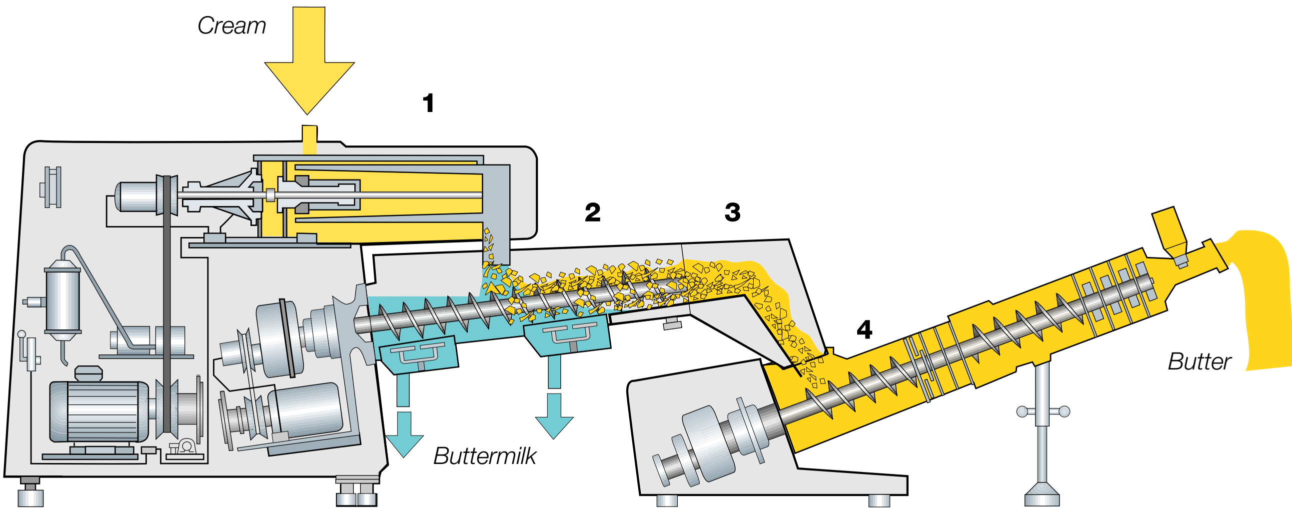

Fig. 12.6 A continuous buttermaking machine
1 Churning cylinder
2 Separation section
3 Squeeze-drying section
4 Second working section

A sectional view of a buttermaker is shown in figures 12.6 and 12.7. The cream is first fed into a double-cooled churning cylinder (1) fitted with beaters that are driven by a variable-speed motor.

Rapid conversion takes place in the cylinder and, when finished, the butter grains and buttermilk pass on to a separation section (2), also called the first working section, where the butter is separated from the buttermilk. The first washing of the butter grains takes place en route with recirculated chilled buttermilk. The separation section is equipped with a screw that initiates the working of the butter while conveying it to the next stage.

As it leaves the separation section the butter passes through a conical channel and a perforated plate, the squeeze-drying section (3), where any remaining buttermilk is removed. The butter grains then proceed to the second working section (4). Each working section has its own motor, so that they can operate at different speeds for optimum results. Normally the first screw rotates at twice the speed of the screw in the second section. Following the last working stage, salt may be added by a high-pressure injector in the injection chamber (5).

The next section, the vacuum working section (6), is connected to a vacuum pump. In this section it is possible to reduce the air content of the butter to the same level as for conventionally churned butter.

The final working stage (7) is made up of four small sections, each of which is separated from the adjacent one by a perforated plate. Perforations of different sizes and working impellers of different shapes are used to optimise treatment of the butter. In the first of these small sections there is also an injector for final adjustment of the moisture content. Once regulated, the moisture content of the butter deviates less than ~0.1%, provided the characteristics of the cream remain the same.

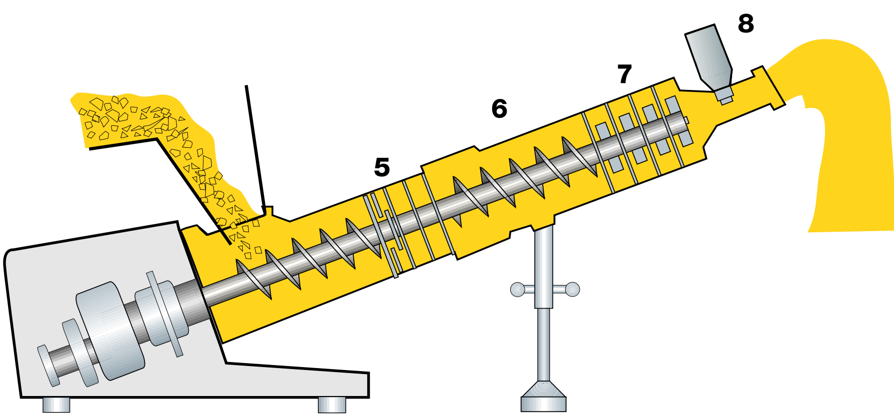

Fig. 12.7 The vacuum working section
5 Injection section
6 Vacuum working section
7 Final working stage
8 Moisture control unit

Transmitters (8) for moisture content, salt content, density and temperature can be fitted in the outlet from the machine. The signals from the instruments can be used for automatic control of these parameters.

The finished butter is discharged from the end nozzle as a continuous ribbon into the butter silo for further transport to the packing machines.

Continuous buttermaking machines are available for production capacities of 200 – 5 000 kg/h butter from sour cream and 200 – 10 000 kg/h butter from sweet cream.

New trends and possibilities for yellow fat products

Since the turn of the century the pattern of edible fat consumption has shifted from butter to margarine. During the 80s there was also a clear trend towards reduced fat and low-fat products.

These changes in consumer habits can be explained by the increasing use of prepared foods and heightened health-consciousness.

As was mentioned in the introduction to this chapter, some new yellow fat products appeared on the market back in the 70s. The general advantage claimed for them was that they were easier to spread at refrigerator temperature, while some were also specifically developed to satisfy the increasing demand for products of lower fat content without sacrificing the taste of butter. Two examples from Sweden, where they are now firmly established on the market, are *Bregott* and *Lätt & Lagom*.

There is a clear trend towards reduced fat and low-fat products.

Bregott

Bregott is a spread of 80% fat content, of which 70 – 80% consists of milk fat and 20 – 30% of liquid vegetable oil such as soybean or rapeseed oil. The manufacturing technique is the same as for butter.

As Bregott contains vegetable oil, it is classed as a margarine. Bregott can also be used for cooking.

Lätt & Lagom

Lätt & Lagom is legally defined in Sweden as a “soft” margarine (the IDF standard suggests the designation – or low fat blend), which means that the fat content must be between 39 and 41 grams per 100 grams of product. This type of spread is also called a *minarine.*

The product is intended solely as a spread. It should not be used for cooking or baking, and definitely not for frying, on account of its high protein content. The manufacturing process is essentially the same as for margarine.

Butter oil – or strictly speaking anhydrous milk fat (AMF) – and soybean or rapeseed oil are mixed in proportions determined by the requirements of good spreadability at refrigerator temperature. Following the mixing an appropriate amount of the water phase, also containing protein harvested from ordinary cultured buttermilk, is added. The whole mixture is pasteurised in a plate heat exchanger and finallly chilled while being worked in special scraped-surface coolers and pin rotors.

The presence of AMF and buttermilk protein gives the product a butter-like aroma.

A new method of manufacturing these products, and butter too, is the TetraBlend process.

The TetraBlend™ process

The process is a combination of two known process steps: cream concentration, and crystallisation combined with phase inversion.

The cream is usually concentrated to 75 – 82% fat content in a hermetic separator, where the heavy phase is skimmilk, here also called buttermilk,

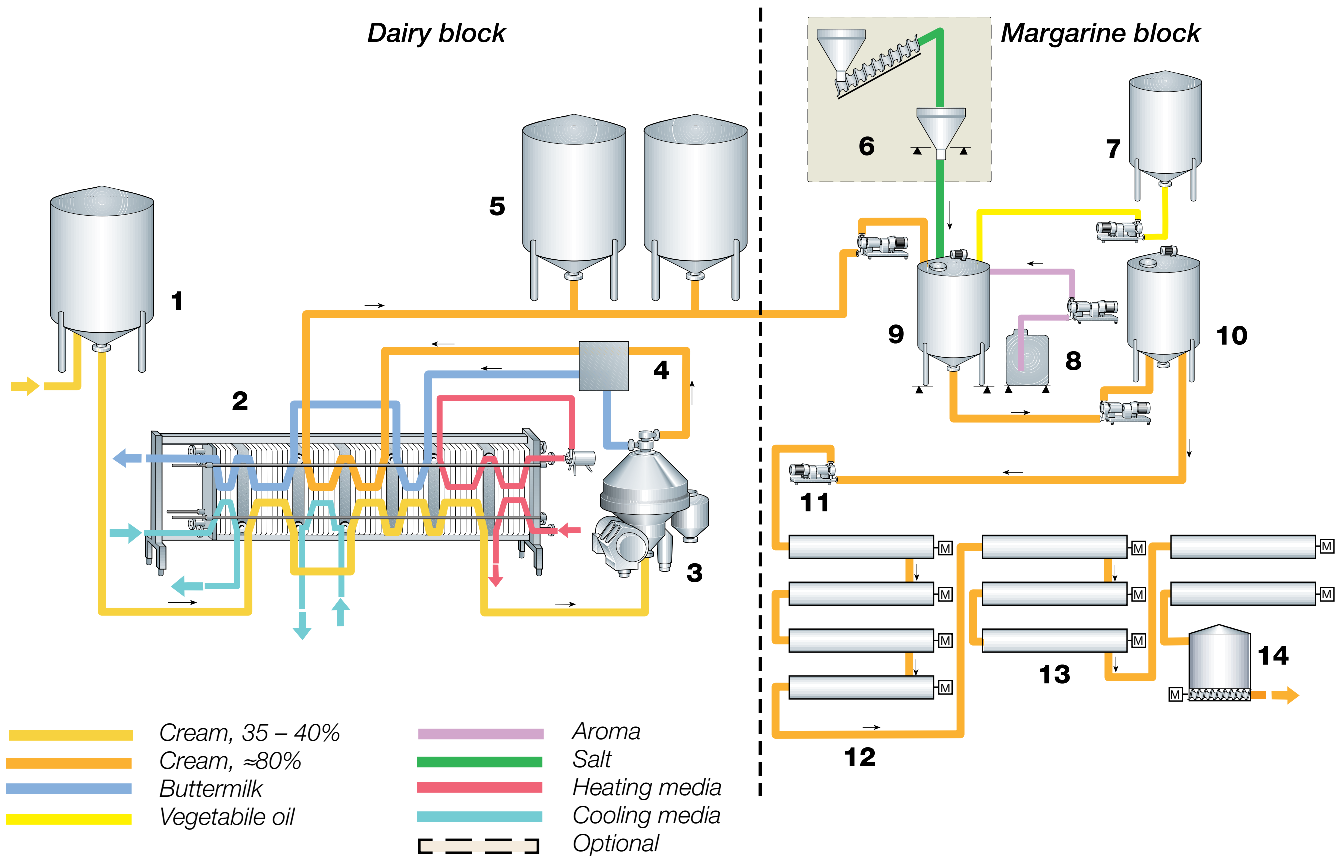

***Fig. 12.8** The TetraBlend process line for the production of butter and dairy spreads.*

Dairy block
1 Cream tank
2 Plate heat exchanger
3 Centrifugal cream concentrator
4 Cream standardisation
5 Pre-crystallisation tanks

Margarine block
6 Salt dosage, optional
7 Vegetable oil tanks
8 Aroma dosage
9 Mixing
10 Buffer tank
11 High pressure pump
12 Scraped surface cooler
13 Pin rotors
14 Silo with screw conveyor in the bottom

which contains *less fat* than the buttermilk from traditional butter processes. In most cases skimmilk has a higher by-product value than buttermilk.

For production of spreads of 40 to 60% fat content the concentrated cream of approximately 75 – 80% fat is diluted with water before processing, which results in a lower content of proteins and lactose. When cream of the same fat content as that of the final product is processed, the higher content of proteins and lactose impairs the flavour of the spread.

A further advantage of using concentrated cream as a base for low-fat products is that no extra emulsifier is required, as the natural emulsifiers in the milk are available in the cream.

The process line

The process line is built around two blocks:

1. A typical “dairy block “with cream concentration, pasteurisation and cooling

2. A typical “margarine block” with preparation of the mix and phase inversion accompanied by working and cooling.

The process line is illustrated in figure 12.8.

Dairy block (to the left of the broken line in figure 12.8.)
The process starts with pasteurised cream of 35 to 40% fat content. As the cream may come from another creamery or a local cream storage tank, its temperature must be adjusted to 60 – 70°C before it enters the cream concentrator, a hermetic centrifugal machine. The degree of concentration, i.e. the cream fat content, is automatically controlled by the continuous standardisation device described in chapter 6.2. Fat contents of up to 82% can be attained, (on special request even up to 84%, but then at the expense of a high fat content, more than 10%, in the skim phase). Following fat standardisation the cream is cooled to 18 – 20°C before being routed to a holding/pre-crystallisation tank.

Margarine block (to the right of the broken line)
This part of the process line starts with a batching station where the product mix is prepared. Various ingredients are mixed together according to the recipe for the product in question. Thus concentrated cream is mixed with appropriate volumes of vegetable oil, salt and water phase, in that order. After thorough mixing the mixture is pumped into a buffer tank (10). A new batch can then be prepared.

The process is continuous from the buffer tank, from which the product mix is taken to the high pressure pump (11). It is then fed into the scraped-surface coolers (12), where phase inversion takes place. Before final cooling the spread is held and worked by pin rotors (13). Leaving the final cooling stage, the product enters the storage silo (14) from where it is pumped into the filling machine, often a tub filling machine.

The whole process is controlled from a process computer and a recipe computer.

Packaging

There are basically three ways of transporting butter or dairy spreads from the machine to packaging:

1. The product is discharged into a silo with a screw conveyor at the bottom. The conveyor feeds the product to the packaging machine.
2. The product is pumped direct to the packaging machine.
3. Transfer by means of trolleys filled with product. The trolleys are often fitted with screw conveyors. A combination of these methods is also possible.

Butter can be packed in bulk packs of more than 5 kg and in packets from 10 grams to 5 kg. Various types of machines are used, depending on the type of packaging. The machines are usually fully automatic, and both portioning and packaging machines can often be reset for different sizes, for example 250 g and 500 g or 10 g and 15 g.

The wrapping material must be greaseproof and impervious to light, flavouring and aromatic substances. It should also be impermeable to moisture, otherwise the surface of the butter will dry out and the outer layers become more yellow than the rest of the butter.

Butter is usually wrapped in aluminium foil. Parchment paper, once the most common wrapping material, is still used but has now been largely replaced by aluminium foil, which is much less permeable.

After wrapping, the pat or bar packets continue to a cartoning machine for packing in cardboard boxes, which are subsequently loaded on pallets and transported to the cold store.

Figure 12.2 shows the transport of butter from churning equipment to packaging machines.

Dairy blends and spreads are mostly packed in tubs holding 250 – 600 grams.

Cold storage

For the sake of consistency and appearance butter, dairy blends and spreads should be placed in cold storage after packing and kept at +5°C.

Experimental buttermaking methods

There have been many attempts to develop new manufacturing methods with the object of producing butter with no undesirable properties. One of these methods, the NIZO method (Dutch), uses sweet cream as the raw material.

As much buttermilk as possible is drained off after butter formation. This sweet buttermilk consequently contains most of the copper ions. Externally produced lactic acid is then added, together with a special starter culture, to produce the bacterial souring that gives the butter the required aroma. This method has a relatively good yield and the buttermilk is sweet. The butter has a good taste, good keeping qualities and high oxidation resistance.

It is very likely that several similar methods will be adopted in the future if present tests fulfill their promise. However, there are still some obstacles. The methods cannot be used in countries where the addition of foreign substances (lactic acid) to dairy products is prohibited.