Paper No. 7 Technology of Milk and Milk Products

Module 9: Technology of Butter making – Batch and Continuous Processes

Introduction

There are basically two kinds of butter (i) White and (ii) Table butter. Other variants may be cultured butter/Ripened cream butter, Whipped butter, herbal butter etc. Table butter contains added edible natural colour (yellow) and common salt whereas White butter is devoid of these two additives.

FSSA requirements for Butter

Butter means the fatty product derived exclusively from milk of cow and/or buffalo or its products principally in the form of an emulsion of the type water-in-oil. The product may be with or without added common salt and starter cultures of harmless lactic acid and/or flavour producing bacteria. Table butter shall be obtained from pasteurized milk and/or other milk products which have undergone adequate heat treatment to ensure microbial safety. It shall be free from animal, body fat, vegetable oil and fat, mineral oil and added flavour. It shall have a pleasant taste and flavour free from off flavour and rancidity.

When butter is sold or offered for sale without any indication as to whether it is Table or Deshi butter, the standards of Table butter shall apply.

FSSA Requirements for Butter

<table>
<thead>
<tr>
<th></th>
<th>Table butter</th>
<th>Desi/Cooking butter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture, Max.</td>
<td>16.0%</td>
<td>-</td>
</tr>
<tr>
<td>Milk fat, Min.</td>
<td>80.0%</td>
<td>76.0%</td>
</tr>
<tr>
<td>MSNF (Curd), Max.</td>
<td>1.5%</td>
<td>-</td>
</tr>
<tr>
<td>Salt, Max.</td>
<td>3.0%</td>
<td>-</td>
</tr>
</tbody>
</table>

There are four basic stages involved in any butter making process. These include:

1. Concentration of the fat phase of milk by separation of milk.
2. Crystallization of the fat phase of milk by cooling and ageing.
3. Destabilization of the oil-in-water (o/w) emulsion.
4. Formation of a plasticized (water-in-oil) w/o emulsion.
Butter making in batch churn

Though batch churns are still in use, they are rapidly being replaced by continuous butter making machines (CBMM).

The steps involved in buttermaking by batch method are as follows:

I. Preparation of cream

The steps involved in preparation of cream for buttermaking are standardization of cream (38-41% fat), pasteurization (80°C/16 sec.), cooling (~ 5°C) and ageing (5-8°C/6-12 h) of cream. Standardization of cream fat will help to obtain ‘exhaustive churning’ i.e. churning in normal time period (~ 45-60 min for batch) with minimal fat loss in buttermilk. Ageing of cream helps in improved partial solidification of fat that helps in imparting good body and texture to butter and minimizes fat loss in buttermilk.

II. Churning of cream and draining of buttermilk

The cream is churned after slight raising the temperature of cream (i.e. 9-11°C) from the ageing temperature; the cultured cream may be churned to obtain ‘Cultured butter/Ripened cream butter’. Butter was traditionally made in cylindrical, conical, cubical or tetrahedral churns with adjustable speed. Axial strips and dashers are fitted inside the churn. In batch churns, the mechanical stress is created by rotating the partly filled churn so that the cream is lifted up the ascending wall of the churn and then cascades to the base. In such churns, aeration and foam formation and collapse are relatively important, in a process taking 40-60 min. In the churning process, the cream is agitated violently to breakdown the fat globules, causing the fat to coalesce into butter grains. The churn is usually filled to 40-50% of its capacity, to allow space for foaming.

Modern churns have a speed range that permits selection of the most suitable working speed for any set of butter parameters. Upon churning, the cream is split into two fractions: butter grains and buttermilk. The machine is stopped when the grains have reached a certain size (peanut), and then the buttermilk is collected separately in buttermilk silo.
The size of churns has increased greatly in recent years. Churns of 8,000-12,000 lit./batch capacity or more are used in large creameries.

III. Washing of butter grains

It is a common practice to wash the butter with pasteurized chilled water to remove any residual buttermilk and milk solids; this helps in reducing the curd (i.e. SNF) content (limit of 1.5% as per FSSA) of butter.

IV. Salting of butter

Salting of butter helps in enhancing the flavour and also extends the shelf life of butter. The salt should be chemically pure, extra-fine (pulverized) and quickly and completely soluble. Salt is normally added dry, but can be added in the form of brine too. Recommended percentage is limited to 2 % for long-life butter. Too much salt can lead to presence of free moisture in the finished product and make the product prone to flavour defects, if stored for a long time.

V. Working of butter

In order to subject the butter to working process, the batch butter churns are equipped with either working vanes or working rollers. The churn is allowed to revolve at a speed much lower than that of churning for a specific period of time (20 ÷ 35 min) in order to ‘work’ the butter. 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 (maximum 16 %) is obtained. In most churns, there is a provision for vacuum working so that butter contains less air (< 1%) and is more dense and compact. If butter is to be salted, salt is spread over the surface of pre-worked butter in batch production. After salting, the butter must be worked further to ensure uniform distribution of the salt.
Proper working results in uniform dispersion of aqueous phase droplets in the continuous fat phase coupled with their microscopic size, restricts microbial growth due to the limited nutrient availability.

**VI. Unloading of butter**

Butter from the batch churn may be dropped onto previously clean and sterilized butter trolleys, wheeled to the packer, and then either tipped or shoveled into the feed hopper.

**VII. Packaging of butter**

The butter is then portioned, via a continuous packaging machine, into vegetable parchment paper which is then enclosed in a cardboard box. The sizes packed may be 10 g chiplet, 100 g block, 500 g block and even 400 g tinned butter; later one is exclusively packed for armed forces. White butter may be packaged in bulk in cardboard box lined inside with polyethylene in 15 kg packs.

**Continuous Butter Making**

With increasing volume sales of Table butter, the dairy plants are now switching over from conventional batch buttermaking to continuous ones, ensuring consistent quality of product throughout the continuous run of the continuous butter making machine.

Methods of continuous butter making were introduced at the end of the 19th century. The continuous butter making processes are of two main types:

I. Fritz and Senn methods which employs a medium fat cream (40-45 %).
II. Methods involving production of high fat (> 80 %) cream.

These days, the Fritz process is most popular, although in USSR the Meleshin high fat cream method still appears to be widely used. In India, all the continuous butter making machines (CBMM) operates on Fritz principle only.
Principles of Continuous Butter Making

There are main three principles of continuous butter making which are dealt herein:

I. **Flotation or Agglomeration:** The principle is the same as in batch method, but the process is faster. Agitation of cream and fine foam is developed by blades revolving at high speeds (2000 rpm); there is very rapid (< 3 s) formation of fat globule clusters which become butter granules and are carried to working section, while the buttermilk is expelled continuously. The resulting grains, washed or unwashed are worked in a kneading section.

   Applied in Contimab, Westphalia, Silkeborg machines.

II. **Concentration or Inversion process:** Cream (30-40 % fat) is concentrated in a special separator to a fat content (80-82 %) close to that of butter. After standardization, the concentrated butterfat is cooled and worked. The concentrated cream being unstable, phase inversion takes place by cooling at the continuous churn intake, and mechanical friction provided by propulsion screws or agitators.

   Applied in Alfa process (Sweden), New-way process (Australia) and Meleshin process (USSR).

III. **Emulsion or Combination:** This involves concentration of 30-40 % fat cream to a fat content of 85-99 %; during concentration the emulsion is broken. Thereafter, standardization of composition is carried out by addition of water or an aqueous solution of salt in the oil phase, followed by re-emulsification, cooling and working.

   Applied in Cherry-Burrell and Creamery Package (USA).

In this module, focus has been laid only on Fritz principle of continuous buttermaking since Indian dairy plants have adopted it. Continuous machines are available for production capacities ranging from 200-10,000 kg of butter/h.

**Continuous Butter Making By Fritz Process**

*Preparation of cream:* The cream is prepared in the same way as for conventional churning (standardized to slight higher i.e. 45% fat, pasteurized, cooled and aged), before being continuously fed from the cream tank to the butter maker.
**Churning of aged cream:** The cream is fed into a churning cylinder fitted with beaters that are driven by a variable-speed motor (~1000-3000 rpm). This forms butter grains in about 2 sec. and the mixture of butter grains and buttermilk pass onto the next section.

**Separating of buttermilk:** The section next to churning section consists of a perforated rotating (~ 35 rpm) drum, wherein the buttermilk is drained and collected separately, and the butter grains are consolidated due to the tumbling action of the cylinder.

**Washing of butter grains:** The washing of the butter grains takes place en route with recirculated chilled buttermilk. In some buttermaking machines, the butter granules are not washed with water. Washing of butter granules and filter grids in Contimab machines with buttermilk at 2-4°C reduced fat losses and improved butter quality. By controlling the churning temperature through use of chilled water, the buttermilk fat content is kept to a minimum.

**Working of butter and brine injection for salting:** The continuous butter maker may have one or even two working sections, depending on the manufacturer. In case of machine with two working sections, the washed butter passes onto the first working section, wherein working is carried out under the action of two contra-rotating augers at adjustable speeds, followed by the perforated plates and impellor blades. Both water and brine are usually injected before working in vacuum. A metering pump (positive displacement pump) with a device for adjusting the flow rate distributes the salt uniformly in butter. The strength of brine is about 50-60 % in order to obtain 2-3 % salt in the final product. The salt used in preparing brine should have particle size between 50-100 μm. The colouring agent (annatto, β-carotene) may be added to the brine (but kept agitating during brine injection).

**Vacuum working:** The worked butter then passed through a vacuum section (500-600 mm Hg in vacuum chamber) to obtain a denser, finer textured product with < 1 % air (without vacuum up to 8 % air may be present) incorporation.
Final working of butter: The second set of augers in the second working section removes the butter from vacuum section and forces it through a further set of orifice plates and blades which completes emulsification.

Discharge of butter: The machine may be set up to discharge directly into a bulk handling system i.e. feed hopper of a bulk packer. Alternatively a bulk butter silo maybe placed before the packaging machine. The butter pumps use large, interlocking rotors operating at low revolutions.

Packaging of butter: The most efficient method of packing consumer portions is by direct feed from the buttermaker via a silo to the filler. Most consumer butter packs use a film wrap i.e either vegetable parchment, or a parchment lined aluminium foil; final packing is done in a cardboard box (100 g, 500 g sizes).

Preparing Cultured Butter in a Continuous buttermaker

Sweet cream is pasteurized, cooled to 6-8°C in a plate heat exchanger, ripened at this temperature and tempered at about 10°C. Ripened cream is handled in a similar way with an additional pH-dependent (desired pH ~ 5.3) regulated cooling to prevent over-souring. Variations in the fat content of the cream are associated with fat losses in buttermilk, and it is therefore essential that the fat content of the ripened cream should not fall below 35-38 %.

Measurement and control of moisture and salt in Continuous butter making machine

The Brabender measuring device, operating on the dielectric principle, is generally placed at the end of the pressing section of CBMM or built-in in the adjoining butter discharge tube. The plate of the electrode is fixed under a nozzle from the butter making machine. When butter with slightly insufficient moisture content flows onto the plate, the moisture content is recorded in recorder and the required amount of water is added automatically by means of a piston pump connected to the moisture meter. The automatic regulation of moisture content of the butter is made possible by electrically actuating a water-dosing pump.
The gravimetric method, automated Karl Fischer method and conductivity and dielectric methods have posed problems when applied to continuous butter making. Infra Red (IR) methods have shown most promise, especially attenuated total reflectance of IR energy. Detection of NaCl through titration of Cl\(^-\) with AgNO\(_3\) is becoming expensive, and an alternative method is to use Orion ion-selective electrode.

**Energy consumption and fat loss in continuous butter making**

With increasing fat content of cream, energy consumption and fat losses decreased, but the reduction in fat losses became less pronounced as churning temperature increased. Prolonged ageing of cream after final cooling reduced energy consumption. Butterfat losses in buttermilk, during continuous butter making with Paasch and Silkeborg HCT 1A & 2A machines (1600-2300 kg butter/h capacity) averaged 0.49 and 0.70%.

The fat content of cream and speed of shaft rotation had the greatest effects on the extent of fat loss when using HCT-1 continuous buttermaker of Paasch and Silkeborg make (1500 kg butter/h).

**Automation and controls**

The control procedures recommended to be used in Continuous buttermaking include the installation of digital tachometers to indicate churning speed (± 1 rev/min) and working speed (± 0.1 rev/min); the control of the fat content of the cream at 41 ± 1%; the control of cream temperature to ± 0.5°C; close control of the speed of cream pumps; and the use of centrifugal pumps for salt dosing.