PAPER NO. 7 Technology of Milk and Milk Products

MODULE 24 Technology of Cheese Manufacture – II: Soft and Hard cheeses

Introduction

In previous module (No. 23) the classification of cheeses were dealt, which may be based on several factors including 'firmness' of the cheese. In this module the technology of manufacture of 'Soft' as well as 'Hard' cheese varieties will be dealt.

The specifications for cheese as per FSSAI are collated in Table 1, which is based on the firmness of the cheese viz., soft, semi-soft, semi-hard, hard pressed, etc.

Table 1. Category of cheeses and their specifications as per FSSAI

Cheese type	Moisture (%)	Fat on dry matter (%)
Hard pressed cheese	Max. 39.0	Min. 48.0
Semi hard cheese	Max. 48.0	Min. 40.0
Semi soft cheese	Max. 52.0	Min. 45.0
Soft cheese	Max. 80.0	Min. 20.0
Extra hard cheese	Max. 36.0	Min. 32.0
Mozzarella cheese (soft cheese)	Max. 60.0	Min. 35.0

Classification based on Firmness (moisture content)

All cheeses, whether rennet or acid set, can be classified as soft, semi-soft (semi-hard), hard, or very hard, depending on their moisture content. Categorizing cheeses by moisture content or firmness is a common practice. The lines between '**Soft**', '**Semi-soft'**, '**Semi-hard'**, and '**Hard**' are arbitrary. The factor that controls cheese hardness is moisture content, which depends on the pressure with which it is packed into moulds, and also based on the aging time.

Semi-soft cheese: Semi-soft cheeses and the sub-group, **Monastery** cheeses have high moisture content and tend to be mild-tasting. Some well-known such cheese varieties include **Havarti**, **Munster** and **Port Salut.**

Medium-hard cheese: Cheeses that range in texture from semi-soft to firm include Swiss-style cheeses such as **Emmental** and **Gruyere**. The same bacteria that give such cheeses their eyes also contribute to their aromatic and sharp flavours. Other semi-soft to firm cheeses includes **Gouda**, **Edam**, **Jarlsberg** and **Cantal**. Cheeses of this type are ideal for melting and are often served on toast for quick snacks or simple meals.

Semi-hard or hard cheese: Harder cheeses have lower moisture content than softer cheeses. They are generally packed into moulds under greater pressure and aged for a longer time than the soft cheeses. Cheeses that are classified as semi-hard to hard include Cheddar, originating in the village of Cheddar in England. **Cheddar** is one of a family of semi-hard or hard cheeses (including **Cheshire** and **Gloucester**), whose curd is cut, gently heated, piled, and stirred before being pressed into forms. **Colby** and **Monterey Jack** are similar but milder cheeses; their curd is rinsed before it is pressed, washing away some acidity and minerals. A similar curd-washing takes place when making the Dutch cheeses **Edam** and **Gouda**.

Natural cheese is most often classified according to moisture content. Very high moisture cheeses, such as cream and cottage, are not aged and, thus, are often called 'Fresh cheeses'. Hard cheeses also referred to as 'grating cheese' such as **Parmesan** and **Pecorino Romano** are firmly packed into large forms and aged for months or years.

The classification of cheese based on moisture content is depicted in Tables 2.

Table 2 Classification of cheese based on moisture content

Consistency	Maximum moisture (%)	Minimum fat-on-dry matter (%)
Hard grating	34.0	32.0
Hard	39.0	50.0
Semi-soft	50.0 (> 39.0)	50.0
Semi-soft, part skim	50.0	45.0 (< 50.0)
Soft	Not specified	50.0

Generalized cheese manufacturing procedure

The temperatures, times, and target pH for different steps, the sequence of processing steps, the use of salting or brining, block formation, and aging vary considerably between cheese types.

The production of all varieties of cheese involves a generally similar protocol (Figure 1), various steps of which are modified to give a product with the desired characteristics. The description of some important steps in cheese making is as follows:

Standardization of milk*:* Milk is standardized before cheese making to optimize the protein to fat ratio to obtain good quality cheese with high yield. The ratio of casein to fat (C/F) determines cheese composition in terms of the amount of fat in the total solids (TS) portion of cheese, i.e. fat-in-dry matter (FDM).

Pasteurization of milk: The cheese milk is subjected to mild pasteurization (72-74^{o}C/15 sec.) to reduce the number of spoilage organisms and inactive heat labile enzymes, and improve the environment for the starter cultures to grow. Pasteurization of cheese milk also leads to higher yield when compared to that obtained from raw milk.

Bactofugation of cheese milk: Bactofugation of milk may be used to reduce the aerobic and anaerobic spore count in milk for cheeses in which these bacterial types (Gouda and Swiss types) may create defects.

Addition of calcium salt*:* In addition to milk solids, calcium chloride (@ 0.01-0.02% by wt.) may be added to milk during certain seasons, especially to cow milk, to enhance enzymatic milk clotting.

Inoculation of cooled milk*:* Milk is cooled after pasteurization to about 90°F (32°C) and then inoculated with starter culture. Thereafter, the milk is left at such temperature for 30-40 minutes to ripen. Such temperature will be conducive for the starter bacteria to grow. The ripening step allows the bacteria to grow and begin fermentation, which lowers the pH and develops the flavor of cheese.

Renneting and curd formation: Coagulation, or clotting of the milk, is the basis of cheese production. Coagulation is brought about by physical and chemical modifications to the constituents of milk and leads to the separation of the solid part of milk (the curd) from the liquid part (the whey). The enzyme rennin is used for coagulation, aided by the starter activity. Most of the fat and protein from the milk are retained in the curd, but nearly all of the lactose and some of the minerals, protein, and vitamins escape into the whey.

The rennet is a proteolytic enzyme that is added to milk (usually 1 g/100 lit. milk) to form a curd. The enzyme is usually diluted in cold water and added uniformly to milk in the vat. It takes about 30 minutes to form a curd, firm enough for cutting.

Cutting the curd and cooking: Cheese maki**n**g is basically a de-watering process. The curd is allowed to ferment until it reaches pH 6.4. After the curd is formed, it is cut into small pieces to speed up whey expulsion and increase the surface area. The curd particles are cut into various sizes, depending on the variety of cheese being made. Cutting the curd into small cubes (~1 cm^3) reduces the moisture content of the curd, whereas creating larger cubes increases the moisture content. Cutting leads to expulsion of whey from the cheese curd, the whey may be used as a medium to cook (scald) the cheese curd.

In case of Cheddar cheese, the curd is then cut with cheese knives into small pieces and heated to 100°F (38°C) in about 30-40 minutes. Raising the temperature of cheese curd leads to greater expulsion of cheese whey from the curd, enhance the activity of starter culture (since temperature is near their optima for growth) and result in more firm cheese curd. Cooking of cheese curd contracts the curd particles and acts to remove whey, develop texture, and establish moisture control. The cut curds and whey are heated and agitated.

Draining of whey: The drainage step involves separating the whey from the curd. Drainage can be accelerated by either heat treatment or mechanical treatment, such as cutting, stirring, oscillating, or pressing. The whey is drained from the vat and the curd forms a mat.

For some cheeses, special applications and procedures occur immediately before, during, or after the draining stage. For example, internally ripened, or blue veined, cheeses (e. g., Blue, Roquefort) are usually seeded with penicillium powder prior to drainage. Cooked hard cheeses (e. g., Parmesan) are stirred and warmed to accelerate and complete the separation of the whey.

Texturizing the curd/Cheddaring: The curd mats are cut into sections and piled on top of each other and flipped periodically. This step is called cheddarin**g.** Cheddaring helps to expel more whey, allows the fermentation to continue until a pH of 5.1 to 5.5 is reached, and allows the mats to 'knit' together and form a tighter matted structure.

Knitting, or transforming, the curd allows the accumulating lactic acid to chemically change the curd. This step leads to the characteristic texture of different cheeses. During the curd knitting stage, Provolone and Mozzarella cheeses are pulled and processed (these cheeses are then kneaded, drawn, shaped, and smoothed); a bean gum or other gum type is added to cream cheese to stabilize and stiffen it; and a creaming agent (cream) is added to cottage cheese. During this period, specific pH levels are controlled to produce different varieties of cheese.

Milling of cheese curd: The curd mats are then milled (cut) into smaller pieces to facilitate uniform salting of cheese curd.

Dry salitng or Brining: To salt the cheese, coarse salt is spread over the surface of the cheese or the pressed cheese is immersed in a salt solution. Salting further completes the drainage of the cheese and also affects rind formation, growth of microorganisms and enzyme activity.

For Cheddar cheese, the smaller, milled curd pieces are put back in the vat and salted by sprinkling dry salt on the curd and mixing in the salt. In some cheese varieties, such as mozzarella, the curd is formed into loaves and then the loaves are placed in brine (salt water solution).

Formation of cheese into blocks: The salted curd pieces are placed in cheese hoops and pressed into blocks to form the cheese. Pressing determines the characteristic shape of the cheese by compacting the texture, extruding free whey from the curds, and completing the curd knitting.

Store and Age: The cheese is stored in coolers until the desired age is reached. Depending on the variety, cheese can be aged from several months to several years.

Packaging: Cheese may be cut and packaged into blocks or it may be waxed. Modern cheese packaging protects the food from microorganisms and prevents moisture loss. The ripened cheese packaging involves applying laminated cellophane films to unwaxed cheese surfaces. The most common packaging film consists of two laminated cellophane sheets and a brown paper overlay necessary for shipping. A variation includes a metal foil wrap.

Ripening: During the ripening or curing stage, the cheese varieties acquires unique texture, aromas, appearance, and taste through complex physico-chemical changes that are controlled by adjusting temperature, humidity, and duration of ripening. The purpose of ripening is to allow beneficial bacteria and enzymes to transform the fresh curd into a cheese of a specific flavor, texture, and appearance.

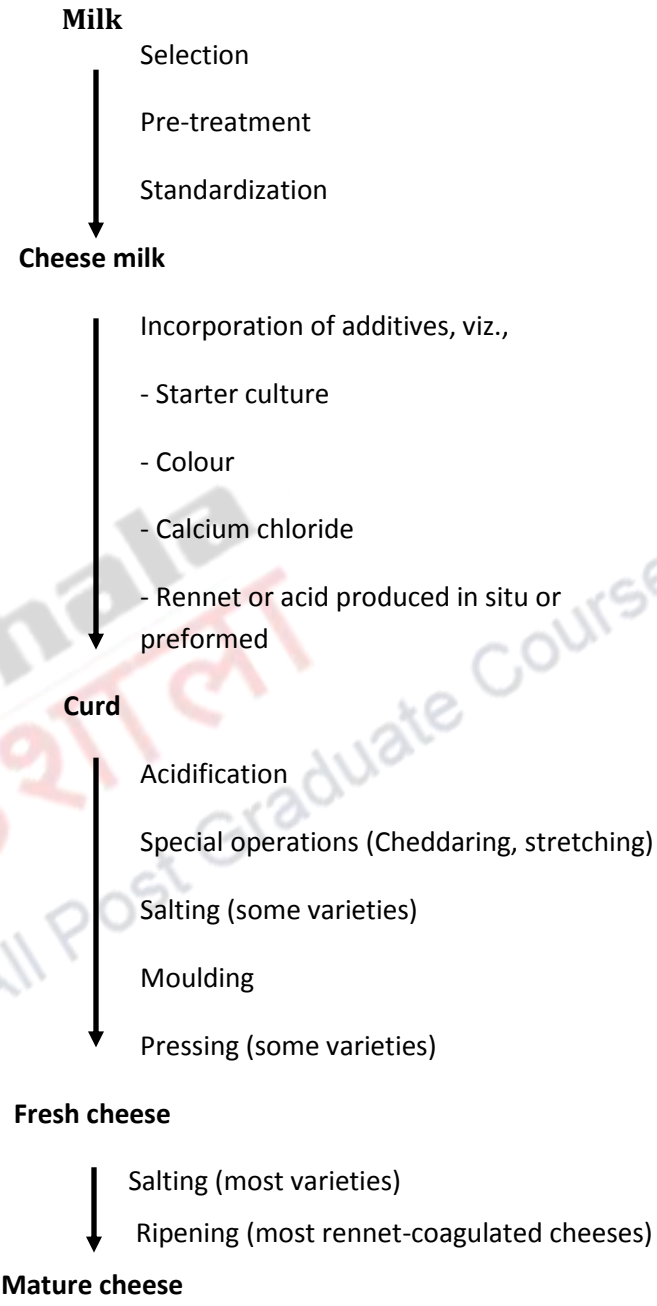

Figure 1. Generalized technique of cheese making

Technology of specific cheese varieties

Now the technology of manufacture of few soft and hard cheese varieties is discussed herein.

I. Technology of Cottage cheese (Soft cheese)

The traditional manufacture of cottage cheese involves the following processing steps:

Usually, the starter is added to the milk together with rennet. Sometimes, the rennet is added 1 to $1_1/_2$ h after inoculation with starter. The process conditions can vary widely, e.g., from acid production at 32°C for 4 to 5 h with 5.0-6.0 % starter added (short-set method), to acid production at 22°C for 12 to 16 h with 0.25-1.0% starter (long-set method). The clotted milk is cut into cubes of a desirable size. The firmness of the coagulum closely depends on the pH and, to a lesser extent, on the rennet action. To obtain a firm curd, the milk is low-pasteurized and a little rennet is added. Usually, acid production is allowed until the pH reaches 4.6 to 4.8. The curd is thoroughly washed to remove most of the lactose and lactic acid. At the same time, the mixture is cooled. The low-fat curd is blended with cream

The milk may also be acidified directly by adding inorganic or organic acids, i.e., the direct-set method. The acid is added at low temperature (i.e. 7°C), while the milk is vigorously stirred until the pH is 4.6. Then, while the milk is at rest, its temperature is raised by ohmic heating. Setting takes about 12 min. Thereafter, the manufacturing process follows the usual procedures. The flavor of the product is often considered to be less satisfactory, presumably due to the lack of starter organisms that produces diacetyl.

The freshly cut curd is left for 10 - 15 min to expel little whey. Consistency and firmness of cottage cheese greatly depend on the rate of heating during cooking. To avoid fusion of the curd grains, the curd and whey mixture should be gently and continuously stirred. During the first stage of cooking (i.e. until 43^oC) some additional acid is produced in curd and whey. If the curd is cooked to higher temperature of (i.e. 55 to 57^oC) and maintained at such temperature for some time, many bacteria are killed and most of the rennet is inactivated.

Usually, the curd is washed three times, the quantity of water added being equal to that of the whey drawn off. Washing reduces the intense acid flavor. Often, 5-20 ppm of activated chlorine is added to the last wash water to prevent growth of undesirable microorganisms. Blending the low-fat curd with cream (10-20% fat sweet or cultured cream, often homogenized) considerably improves the flavor of cottage cheese. The plasma of the cream is believed to be 'absorbed' by the curd, hence the fat globules remain on the outside of the curd granules to 'lubricate' them. The absorption appears to take approximately 30 to 40 min. The product should not whey off or separate 'free cream. Well-soured cream does not yield free cream. Sometimes, stabilizer is added to the cream to prevent this defect.

In spite of all precautions, cottage cheese does not have a long shelf life. Its composition permits growth of microorganisms. Very good hygiene during manufacture and packaging are essential. Sorbic acid may be added to the creaming mix to improve the shelf life. Alternatively, the product may be packaged under CO_2, whereby growth of Gram-negative psychrotrophs is especially inhibited.

II. Technology of Mozzarella/Pizza cheese (Soft cheese)

Mozzarella is a small cheese, weighing 50 to 400 g. The loaf shape is a somewhat flattened sphere. The flavor should not be pronounced. Originally, it was mainly made from buffaloes' milk. Nowadays, it is usually made from cows' milk or from a mixture of cow and buffalo milk. The cheese contains 35.0 to 45.0% fat in the dry matter (FDM), 52.0 to 56.0% moisture, and about 1.0% salt. Being only a few days old, it is little matured and has a rather soft and long consistency.

Low-moisture Mozzarella cheese (45.0-50.0% moisture) is suitable for use as a topping on pizza pie and hence also referred to as 'Pizza cheese'. Currently, large quantities of Mozzarella are made for cooking purposes, especially for use on pizzas. The cheese should have adequate melting properties, i.e., soften on heating, become smooth, and flow. However, the melted cheese should exhibit viscous nature and become solid again when the temperature decreases somewhat.

The following flow chart (Figure 2) provides the cheese making steps followed for Mozzarella cheese.

Technology of Mozzarella cheese

Whole milk is standardized to a protein to fat ratio of 1.46 (typically resulting in a milk composition of 2.37% fat, 3.47% protein and 5.00% lactose) and pasteurized prior to cheese manufacture. The temperature of the milk is brought to 33^{o}C prior to the addition of starter (4%) and held at this temperature for 65 min, when the pH falls from 6.6 to 6.3. At this point rennet is added to the milk. The milk is then allowed to coagulate in about 30 min. The coagulum is then cut into small cube-shaped particles (about 9 mm x 9 mm) and stirred while the temperature of the vat is increased to the desired cooking temperature. Approximately 2.5 hours after the addition of the starter, when the pH falls to 5.9, the whey is drained, and the curd is milled, dry salted and then conveyed to the cooker/stretcher. The curd is cooked at 70-85^{o}C and stretched to obtain the elastic and stringy character of Mozzarella cheese. The cheese is then hooped into 10 kg moulds and cooled. The following day, the cheese is wrapped in a plastic film and stored at temperature below 5^{o}C.

Milk receipt
(Test for chemical and microbial quality - fat, pH, antibiotics, somatic cell count)
⇩
Pretreatment of milk
(membrane concentration - Ultrafiltration)
⇩
Standardization
(2.5-2.7% milk fat)
⇩
Pasteurization
(72-73^{o}C/15 sec)
⇩
Starter culture addition
(*S. thermophilus* + *L. delbreuckii* ssp. *bulgaricus*; 1:1; @ 1.5% by weight of milk at 32^{o}C)
⇩ 40 min
Renneting
⇩ 30 min
Cutting of curd
⇩
Cooking/Scalding
(Raise temp. to 40^{o}C in 30 min)
⇩
Resting
(3 hours)
⇩
Draining of whey
(Whey acidity 0.75% LA; curd pH 5.2-5.3)
⇩
Plasticizing of cheese curd
(85^{o}C water for 10 min; kneading)
⇩
Moulding of cheese
⇩
Chilling in chilled water
(4-5^{o}C/10 min)
⇩
Brining of cheese
(20% solution, 10^{o}C, 3 hours)
⇩
Drying
(2 hours)
⇩
Packaging and storage of Mozzarella cheese
(Vacuum packaging, 5^{o}C)

Figure 2. Flow chart for manufacture of Mozzarella cheese

III. Technology of Cheddar cheese (Hard variety)

Cheddar type cheeses are typically hard with a long shelf life and without a surface flora. The best known is Cheddar: about 50.0% fat in the dry matter (FDM), not exceeding 38.0% water, originally of cylindrical shape, weighing about 30 kg. Nowadays, mostly rectangular blocks of variable size are made. Cheddar and derived varieties are now manufactured all over the world, though primarily in English-speaking countries.

The following flow chart (Figure 3) provides the cheese making steps followed for Cheddar cheese.

Cheddar cheese processing steps

Milk receipt
(Test for chemical and microbial quality - fat, pH, antibiotics, somatic cell count)
⇩
Pretreatment of milk
(Bactofugation, H_2O_2/ lysozyme treatment, membrane concentration/fractionation)
⇩
Standardization
(Casein/fat = 0.70)
⇩
Pasteurization
(72-74^{o}C/15 sec)
⇩
Addition of calcium chloride (especially for cow cheese) and colour (Annatto, β-carotene)
⇩
Acidification
(Use of starter or direct acidification to desired pH)
⇩
Renneting
⇩
Cutting of curd
⇩
Cooking, draining, curd manipulation
⇩
Cheddaring of curd
(Packing, turning, piling, repiling)
⇩
Milling of curd
⇩
Salting
⇩
Hooping
⇩

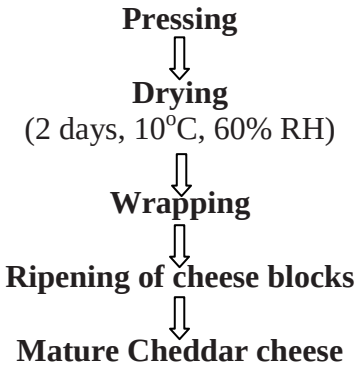

Figure 3. Flow chart for manufacture of Cheddar cheese

Cheddar cheese manufacture

Whole milk is standardized to a protein to fat ratio of 0.70 (resulting in composition - 3.50% fat, 3.00% protein and 4.85% lactose) and pasteurized prior to cheese manufacture. The temperature of the milk is brought to 32°C prior to the addition of starter and rennet (150 ml/1000 lit. of milk). The milk is allowed to coagulate in about 30-40 min. The coagulum is then cut into small cubes (~ 9 x 9 x 9 mm) and the temperature of the vat is increased to the cooking temperature (38°C). About 2.5 hours after the addition of rennet, the vat contents are pumped on to the perforated draining belt. There, the curd moisture is reduced from about 65.0 to 55.0% before the curd is transferred in an air stream to the top of the 'cheddaring tower'. Alternatively, the curd from the vats can be sent to a 'cheddaring machine' where draining, cheddaring, salting and mellowing take place. At this point, the acidity increases considerably and the pH drops from 6.6 (at the start of manufacture) to 6.2. During the cheddaring stage, the curd particles lose their identity and start to bind together under the influence of acidity. During this stage, the moisture content of the curd drops from 55.0 to about 42.0%. When the pH reaches 5.3-5.4, the curd is ready for milling and salting. The curd, on discharge from the cheddaring tower, passes through a mill on to a second belt similar to the draining belt, after which salt is applied to the curd. The salted curd is then pressed under vacuum (in a block former) into 20 kg blocks, wrapped in plastic film and cooled to 18°C within 24 h. It is then stored at 10°C to allow it to mature. The milk finally transforms into a cheese product containing about 32.0% fat and 39.0% moisture.