

Chapter 5

Microbes of Dairy Industry and Major Dairy Products

Products

The products synthesized from milk are called dairy products. Microorganism plays an important role in the manufacture of dairy products. Each dairy product is produced with the help of selected microorganisms. These microorganisms are known as starter.

Starter culture

A starter culture is a microbial preparation used in the initiation of fermentation for the preparation of fermented food and drinks. It consists of culture medium and microorganisms. A small amount of curd added to the milk for converting it into curd is an example for starter culture. The microorganisms include bacteria, yeast and mold. Starter culture is of two types. They are simple starter and mixed starter. A simple starter contains a single strain of microorganisms. Mixed starter contains more than one strain of microorganism. Based on the optimum temperature, the starter is classified into 2 types. They are mesophilic starter and thermophilic starter. Mesophilic starter contains mesophilic bacteria. Mesophilic bacteria grow in moderate temperature around 30°C. Examples of mesophilic bacteria are *Lactococcus lactis* subsp. *cremoris*, *Lactococcus delbrueckii* subsp. *lactis*, *Leuconostoc mesenteroides* subsp. *cremoris*. Thermophilic starter contains thermophilic bacteria. They prefer warmer conditions around 42°C. *Lactobacillus plantarum*, *Lactobacillus casei*, *Lactobacillus delbrueckii* subsp. *lactis*, *Lactobacillus delbrueckii* subsp. *bulgaricus* are the examples of thermophilic bacteria.

Different strains of fungi and bacteria are used for the fermentation of milk in order to produce a wide variety of dairy products viz. curd, yogurt, cheese, kumiss, kefir etc. The main bacteria are lactic acid bacteria that are used for milk coagulation and these can be processed for diverse products.

Fermented milk products are classified into viscous products, beverage products and carbonated products. The primary function of fermenting milk was to extend its shelf life. Some of the fermented milk products are acidophilus milk,

cultured buttermilk, kefir, kumiss, sour cream, villi etc. Yogurt and cheese are also fermented milk products.

Kefir

Kefir is a fermented milk drink, traditionally made using cow's milk or goat's milk. By the addition of kefir grains to milk kefir can be prepared. These are not cereal grains, but grain-like colonies of yeast and lactic acid bacteria that resembles a cauliflower in appearance.

This drink originated in the Caucasus, Eastern Europe and Russia. During the fermentation process changes in the composition of ingredients occur. Lactose, the sugar present in milk is broken down mostly to lactic acid (25%) by the lactic acid bacteria, which results in acidification of the product. *Propionibacteria* further break down some of the lactic acid into propionic acid. Other substances that contribute to the flavor of kefir are pyruvic acid, acetic acid, diacetyl and acetoin, citric acid, acetaldehyde and amino acids resulting from protein break down. The slow-acting yeasts late in the fermentation process, break down lactose into ethanol and carbon dioxide. Depending on the process, ethanol concentration can be as high as 1-2% with the kefir having a bubbly appearance and carbonated taste. This makes kefir different from yogurt and most other sour milk products where only bacteria ferment the lactose into acids.

Kumiss

It is a fermented dairy product traditionally made from Mare's milk. Mare's milk has higher sugar content than cow's and goat's milk and as a result kumiss has a slightly higher alcohol content than kefir. Nowadays, cow's milk is generally used for kumiss, with the addition of sugar to better approximate the composition of mare's milk.

Sour Cream

Sour cream or soured cream is a dairy products obtained by fermenting regular cream with lactic acid bacteria. The bacterial culture which is introduced either naturally or deliberately, sours and thickens the cream. Its name comes from the production of lactic acid by bacterial fermentation, which is called souring.

Buttermilk

Buttermilk is a fermented dairy drink. Traditionally buttermilk is the liquid that is leftover after churning butter. True buttermilk ferments naturally into a thick, tangy cream. These days, buttermilk is usually made by introducing a bacterial culture

to low-fat milk and then heating the mixture.

The starting ingredient for buttermilk is skim or low-fat milk. The milk is pasteurized at 82-88°C for 30 minutes or at 90°C for 2-3 minutes. This heating process is done to destroy all naturally occurring bacteria and to denature the protein in order to minimize wheying off. The milk is then cooled to 22°C and starter cultures of desirable bacteria such as *streptococcus lactis*, *S. cremoris*, *Leuconostoc citrovorum*, and *L. dextranicum* are added to develop buttermilk's acidity and unique flavor. These organisms may be used singly or in combination to obtain the desired flavor. The ripening process takes about 12-14 hrs.

Cultured Buttermilk

Cultured buttermilk was first commercially introduced in the United States in the 1920s. Commercially available cultured buttermilk is milk that has been pasteurized and homogenized and then inoculated with a culture of *Lactococcus lactis* or *Lactobacillus bulgaricus* plus *Leuconostoc citrovorum* to stimulate the naturally occurring bacteria in the old-fashioned product. The tartness of cultured buttermilk is primarily due to lactic acid produced by lactic acid bacteria while fermenting lactose, the primary sugar in milk. As the bacteria produce lactic acid, the pH of the milk decreases and casein, the primary milk protein precipitates causing curdling or clabbering of milk. This process makes buttermilk thicker than plain milk. While both traditional and cultured buttermilk contain lactic acid, traditional buttermilk tends to be less viscous, whereas cultured buttermilk is more viscous. Condensed buttermilk and dried buttermilk remain important in the food industry.

Acidified Buttermilk

It is a substitute made by adding a food-grade acid such as vinegar or lemon juice to milk. It can be produced by mixing 1 table spoon of acid with 1 cup of milk and letting it sit until it curdles, about 10 minutes. In the process used to produce paneer, such acidification is done in the presence of heat.

Curd (Dahi)

Indian curd is a fermented milk product. It is a product obtained from pasteurized or boiled milk fermented by a harmless lactic acid bacteria or other bacterial culture which is retained from the previous days curd.

Lassie

Lassie is prepared by churning curd with water and ice. Ice facilitates the separation of fat globules during churning. Spices, salt or sugar may be added during

consumption. Lassi contains protein and phospholipids.

Butter

Butter may be defined as a fat concentrate obtained by churning cream or curd with or without salt. There are 5 types of butter. On the basis of presence or absence of salt, butter is of 2 types

- Salted butter
- Unsalted butter

On the basis of types of cream used for the manufacture of butter, it is classified into

- Sweet cream butter
- Sour cream butter
- Desi butter or Indigenous type of butter

Desi butter

It is prepared by churning sour cream (curd) to separate fat globules from the liquid portion. The liquid portion after separation of butter is called butter milk which is drained off. This butter has about 80% fat and small quantity of lactose and protein. This is mainly used for the preparation of ghee.

Ghee

It is a clarified butter fat derived from desi butter with no coloring matter. It contains 99.5% fat and 0.5% moisture.

Whey

The watery part of milk that remains after the formation of curds. Whey is full of probiotics and has a bracing acidity. Whey is the byproduct of the manufacture of cheese or casein. Sweet whey is a byproduct produced during the manufacture of rennet types of hard cheese like cheddar or Swiss cheese. Acid whey is a byproduct produced during the making of acid types of dairy products such as cottage cheese or strained yogurt.

Yogurt

It is produced by the bacterial fermentation of milk. Yogurt cultures are the

bacteria used to make yogurt. Lactose fermentation by these bacteria produces lactic acid, which acts on milk protein to give yogurt its characteristic tart flavor and texture. Cow's milk is most commonly used to make yogurt. The milk used may be homogenized or not, even pasteurized or raw. Yogurt is usually produced by using a culture of *Lactobacillus delbrueckii* sub sp. *bulgaricus* and *Streptococcus thermophilus* bacteria. Other *lactobacilli* and *bifidobacteria* are sometimes added during or after culturing yogurt. For producing yogurt, first milk is heated usually at about 85°C to denature the milk proteins so that they do not form curds. After heating the milk, it is cooled to about 45°C. The bacterial culture is mixed in, and that temperature of 45°C is maintained for 4-12hrs to allow fermentation to occur.

Cheese

Cheese is also a dairy product produced in a wide range of flavors, textures and forms by the coagulation of milk protein casein. During the cheese production, the milk is usually acidified and coagulated by adding the enzyme rennet. The solids are separated and pressed into final form. Most cheeses melt at cooking temperature.

The basic steps in cheese making are

- Setting milk (adding starter cultures and coagulant to pre-warmed milk)
- Cutting the coagulum
- Cooking the cut coagulum (curd)
- Removing whey from the curd
- Allowing curd particles to “knit”
- Salting
- Pressing
- Ripening of the finished cheese

Fresh milk obtained from healthy cows or other animals should be cooled rapidly and then promptly delivered to the cheese factory. After the milk is commonly clarified with a centrifuge to remove small extraneous particles and somatic cells. The fat content of the clarified milk may be adjusted depending on the variety of cheese that is to be made. Some cheese is made from raw milk but it is more common to use heat treated or pasteurized milk. Heat treated milk is sometimes preferred because the resultant cheese tends to be more flavorful than that made from pasteurized milk.

Starter culture

One or several species of lactic acid bacteria are commonly added to pre-warmed milk. The small amount of acid produced by these bacteria early in the cheese making process (fermentation) facilitates subsequent clotting of milk by the coagulant. The kind of cheese to be made determines which microorganisms to add to milk. For

eg:- to make cheddar cheese one would use *Streptococcus cremoris* and/or *Streptococcus lactis*, the so-called mesophilic lactic acid bacteria. In contrast, to make Swiss cheese one would use *Lactobacillus bulgaricus* and *Streptococcus thermophilus*, the so-called thermophilic lactic acid bacteria. microorganisms other than lactic acid bacteria sometimes are added together with then when cheese is made. Examples are *Propionibacterium shermanii* for Swiss cheese or molds for blue or camembert cheese. Currently concentrated frozen starter cultures can be purchased and added directly to milk in preparation for cheese making.

Coagulant

After the addition of starter culture, a suitable coagulant is added to milk usually a short time. The coagulant is an enzyme that splits colloidal casein into a carbohydrate-rich peptide fraction and the insoluble paracasein that precipitates in the presence of calcium ions. Traditionally, rennet extract obtained from the fourth stomach of young calves has been used as the coagulant. Recently rennet extract from mature cows and coagulants from fungi have also been used. The fungi *Mucor miehei*, *Mucor pusilus* and *Endothia parasitica* produce coagulants and are used in cheese making.

Cutting the coagulum

Rectangular frames with thin wires, horizontal on some and vertical on others are used to cut the coagulated milk into cubes. Such cutting increases the surface area of the coagulum which facilitates its loss of whey. Cubes of coagulum also can be heated uniformly during the cooking process. Small cubes lead to low-moisture cheese whereas large cubes lead to high moisture cheese.

Cooking the cut coagulum

After the coagulum cutting, the coagulum (curds) cubes suspended in whey are heated at a temperature in a specified time. (eg: 37-38°C in 30 min for cheddar cheese). This heating is accompanied by stirring of the curd- whey mixture and causes the curd cubes to contract and thus express free whey. Cooking also serves to control acid production by lactic starter culture, to suppress growth of some spoilage bacteria, to influence texture of curd and to aid in control of acids in control of the amount of moisture in the finished cheese.

Draining whey

After the completion of cooking, whey is removed from the curd. This can be accomplished by draining whey from a vat that contains the whey-curd mixture using appropriate precautions to prevent the loss of curd. Some additional lactic acid is produced by the starter bacteria during the time needed for removed of curd from the whey.

Knitting of curds

This step allows further production of lactic acid and modification of curd

particles. So they will adhere to each other and form a single mass of cheese. The characteristic texture of a given variety of cheese is partially determined by this process.

Salting of curds

Sodium chloride is applied to curds in one of several ways. Dry salt may be sprinkled on loose curds as in the manufacture of cheddar cheese or it may be rubbed onto the surface of freshly made cheese. Alternatively, freshly made cheese can be immersed in a nearly saturated aqueous solution of salt. Addition of salt contributes to the flavor, texture and appearance of cheese, controls production of lactic acid, suppresses growth of spoilage microorganisms and further reduces the amount of moisture in finished cheese.

Pressing of curds

This step sometimes comes before salting or afterward. Curds are placed into a form, sometimes called a hoop and pressure is applied hydraulically or through use of weights. If cheese with an open texture is desired, external pressure may not be applied. Pressing gives the cheese its characteristic shape and contributes to its compactness. Free whey is expressed and knitting of curd particles are completed during pressing. Use of vacuum chambers during or after pressing can aid in removal of occluded air from cheese and thus gives the product a closely knit body.

Ripening of cheese

The finished cheese is placed in a room with controlled temperature and relative humidity (eg: 4°C and 85% for cheddar cheese) and is held therefore several months to several years, depending on the variety of cheese and the extent of ripening that is desired.

Ripening allows for enzymatically induced changes to occur in the protein and fat fractions of the cheese. These changes transform the freshly made cheese into one with desired and characteristic flavor, texture, aroma and appearance.

Villi

Villi is a mesophilic fermented dairy product found in Finland that originated in Scandinavia. This cultured milk beverage is the results of microbial action of lactic acid bacteria (LAB) and a surface growing yeast like fungus *Geotrichum candidum* present in milk, which forms a velvet like surface on villi. The LAB identified in villi includes *Lactococcus lactis* subsp. *cremoris*, *Lactococcus lactis* subsp. *lactis* biovar. *diacetylactis*, *Leuconostoc mesenteroides* subsp. *cremoris*.

Film jolk (Filmjolk)

It is also known as fil. It is a traditional fermented milk product from Sweden.

It is made by fermenting cow's milk with a variety of bacteria *Lactococcus lactis* and *Leuconostoc mesenteroides*. The bacteria metabolize lactose into lactic acid. The acid gives filmjolk a sour taste and causes casein to coagulate, thus thickening of the final product. The bacteria also produce a limited amount of diacetyl, a compound with a buttery flavor, which gives filmjolk its characteristic taste.

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