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Natural and Cultured Buttermilk

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8.1 Introduction

Milk has been a part of food since the dawn of civilization and also considered as a complete food for human beings. The fermentation of milk is also an ancient technique for the preservation of milk. It is largely used as a means to preserving highly perishable products like milk apart from imparting other benefits to the finished product. This process is carried out by the normal microbiota, while some of the fermentation is intentionally done by using specific microbes for a particular purpose. But the actual process and role of milk fermentation is yet to be completely understood. The inoculation of fresh milk with fermented milks was the process to maintain routine cultures for further use (Kerr and McHale 2001). But now, well-established starter cultures (i.e., lactobacilli, streptococcus, etc.)

are commercially available for the production of various fermented dairy foods, which are discussed elsewhere in this book.

Fermentation is not only used for the preservation of food but also imparts various flavors or tastes, forms, and desired sensory ambiances. Sometime, it also confers several therapeutic and nutritional properties in the finished product. Gradually, consumers have started to recognize the therapeutic and nutritional aspects of fermented foods, which increased the consumption as well as popularity of these foodstuffs (Kaur et al. 2014). The validation of health benefits (i.e., anti-obesity, anti-diabetes, anti-cholesterol level, anticancer, immune modulation, etc.) of some of the fermented milks and its products, for instance, yogurt, has changed the vision of consumers, thereby causing a concomitant rise in its production (Shiby and Mishra 2013).

Nowadays, several functional dairy foods (i.e., probiotic dahi, yogurt, yakult, low cholesterol milk, milk omega-3-milk, etc.), which have a beneficial effect on lifestyle diseases and disorders, are very common in the market. Apart from all these products, buttermilk is one of the classical examples of such products. Buttermilk has a fresh, piquant taste imparted by lactic acid bacteria (LAB), which remains as an integral part of buttermilk even after fermentation. It is not necessary that LAB present in buttermilk elicit probiotic attributes always, as sometimes microflora may also belong to the non-probiotics category. Biochemically, these microbes utilize sugar and yield acids, which results in sourness in buttermilk and also leads to a decrease in pH. Further, the decrease in the pH of milk affects the casein content, which causes the thickening of milk. Both sourness and thickening of buttermilk are imparted by lactic acid produced during the fermentation of milk. Traditional as well as cultured buttermilk has remained an excellent source of nutrition as it consists of good amounts of potassium, phosphorus, vitamin B_{12}, riboflavin, enzymes, protein, and calcium (Conway et al. 2014b).

Buttermilk has wide food applications and can be used for drinking purposes; it may be supplemented to produce sour cream or cultured butter. The name, however, is a bit misleading because it does not contain butter. It is a milky liquid leftover after the churning of cream, which is processed for the preparation of butter. The fat content in buttermilk remains very low. Buttermilk is often used in baking because of its special properties (for instance, sourness, enzymes, and microflora present in this by-product). It can enhance the flavor of various preparations, that is, dips and cakes.

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Further, buttermilk can be used as a battering agent for frying of chops of pork and chicken (Sharma et al. 1998; Raval and Mistry 1999; Shukla et al. 2004; Patel and Gupta 2008). Various studies have also shown the therapeutic importance of the consumption of buttermilk (Larsson et al. 2008; Conway et al. 2013a, 2013b; Fuller et al. 2013; Fu et al. 2014). The objective of this chapter is to cover the different aspects of buttermilk production, its nutritional importance, its health benefits, and its use in different products.

8.2 Fermented or Cultured Milk: An Overview

Cultured milk is produced by the addition or fermentation of LAB and there are wide ranges of fermented milks, which have a number of common characteristics (Driessen and Puhan 1988). The cultures used in fermented milk have their own optimum temperature range for growth. To meet the requirements of cultured milk, that is, mildly acidic and slightly pricking, the content of lactic acid and carbohydrate has to be controlled during the manufacturing of the product. By cooling milk at a specific temperature and at a proper time, acidification can be limited, whereas the excess of carbon dioxide in the product at the end of fermentation can be removed by stirring or deaeration by vacuum. The final taste of cultured milk is the result of a mixture of compounds (e.g., diacetyl flavor is associated with butter and buttermilk) present in a certain ratio in the finished product.

Fermented milk production involves various steps, that is, pasteurization of milk, standardization and homogenization of milk, inoculation culture, breakdown of coagulum, cooling, and packaging. The pasteurization of milk used for the production of cultured milk is carried out to inhibit the pathogens and deactivate the native substances, which are inhibitory to LAB. Additionally, heat treatment denatures whey proteins, which improves the texture of the final milk product. Whey proteins should be denatured, which results in a coagulum that can be stirred easily to realize a smooth and viscous product (Snoeren et al. 1981). This can be achieved by heating milk at 80°C–85°C for 2–5 min (Hillier and Lyster 1979).

Ultra-high-temperature-sterilized milk and other high-temperature-treated milks result in lower viscosity, age-thickening, and a cooked flavor in cultured milks. The lowering of pasteurization temperature of milk results in decreased firmness and retarded acidification. Therefore, homogenization of milk at 55°C and 20 MPa is sufficient and good for

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distribution of fat. Decreasing solids and not fat content in milk results in a taste difference as the product may turn *flat* and *watery*; buttermilk with this defect is said to be *astringent*. Increasing milk solids-not-fat (SNF) leads to a *full* taste, higher viscosity, and a stable cultured milk without wheying-off during storage. The inoculum added causes production of acid, which leads to the formulation of coagulum. The coagulum is generally stirred to get smooth fermented milk. The detailed steps involved in fermented milk production are shown in Figure 8.1. Cultured milks consist of all required nutrition with easy digestibility

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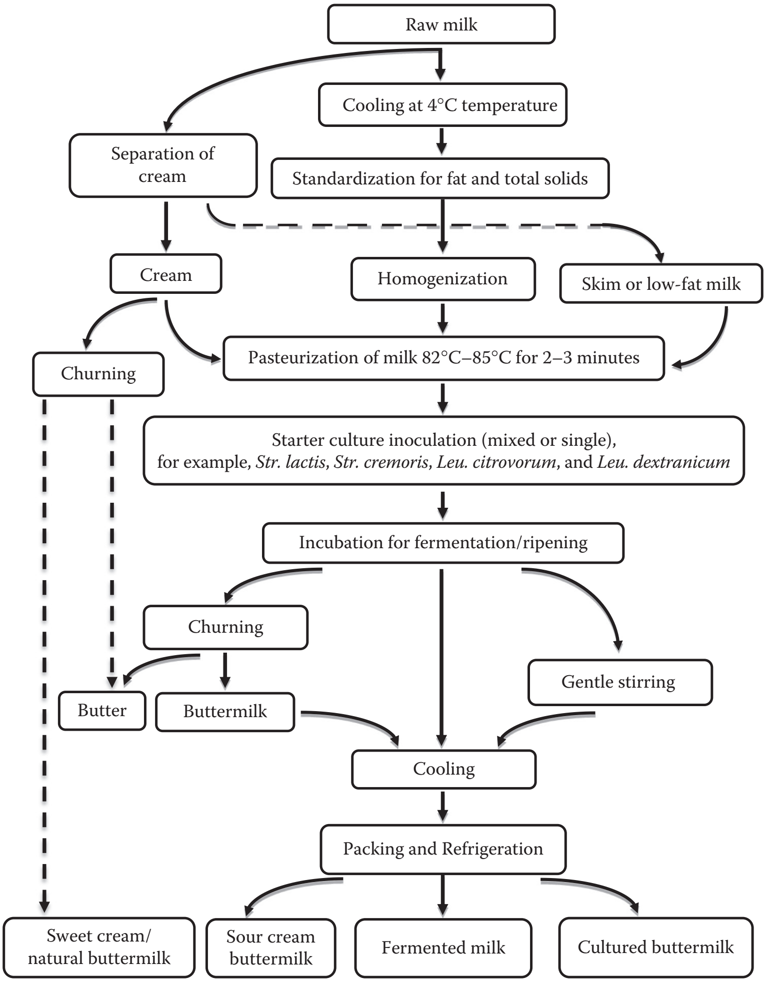

Figure 8.1 Production of fermented milk, cultured buttermilk, and natural buttermilk.

and also impart health benefits. This chapter covers the various aspects of buttermilk, one of the popular forms or examples of cultured milk.

8.3 Buttermilk

Natural buttermilk is a leftover liquid by-product made during the churning of butter. It is a very famous fermented drink in India as well as in other Middle Eastern countries. Cultured buttermilk is probably the easiest fermented milk product to produce but still the exact quantity of production of buttermilk is not assessed. However, the quantity of buttermilk production can be estimated on the basis of production of butter. Approximately, 6.5%–7.0% of total milk produced worldwide is used for the preparation of butter that yields high amounts (around 3.2 million tons/annum) of buttermilk as a by-product. In India, sour buttermilk (lassi) is also obtained during the preparation of butter (makkhan) and curd (dahi). The utility of buttermilk solids was unnoticed and untouched for a long time. However, following a shift in focus of investigation, the consumption of buttermilk, its functions, and its therapeutic attributes are currently explored worldwide. Still, this by-product needs more attention for its many uses; buttermilk-derived health-beneficial products can be developed as it is present in bulk amounts all over the world.

Usually, four types of buttermilk are produced, as shown in Table 8.1 and Figure 8.1. Natural buttermilk is very low in fat (since most of the fat goes to the butter part). It can be consumed as it is or added to recipes in place of water for a nutritional boost.

Cultured buttermilk is another type of buttermilk obtained by intentional acidification of skim milk done by buttermilk starter cultures. It is similar to yogurt in the sense that it is cultured using live beneficial bacteria and can be consumed as a thick and creamy beverage (Conway et al. 2014a, 2014b).

Sweet cream buttermilk (SCBM) is produced from churning of cream. Churning of cream results in the separation of butter and an aqueous phase called SCBM. Generally, cream is not ripened in this case. SCBM has high fat content as compared to skim milk, which can be decreased by centrifuging it or by ultrafiltration (Conway et al. 2014a, 2014b). SCBM also consists of huge amounts of proteins, which are drawn by churning from the fat globule–milk serum interface

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Table 8.1 Different Types of Buttermilk and Their Properties

SWEET CREAM BUTTERMILK	SOUR CREAM BUTTERMILK	CULTURED BUTTERMILK	COMMERCIAL BUTTERMILK
Result of the churning process of cream separated from milk.	End product of churning process of ripened cream.	Produced by culturing of skim milk.	Commercial buttermilk is most widely available in grocery stores.
Produced from fresh, or sweet, milk, which is converted to cream that convert into butter and buttermilk and has a taste similar to regular skim milk.	Made from raw, unpasteurized sour milk. The milk is allowed to sour naturally prior to churning.	Produced by addition of bacterial culture, which provide a rich, fuller and tangier flavor.	Milk is not used to make butter, instead manufactures add bacterial cultures to skim or low-fat cow's milk and let it mature.
Exact taste of the sweet cream milk depends on the flavor of the original milk. For example, goat's milk has a naturally more pungent taste than cow's milk.	Sour cream buttermilk has a tart taste, similar to yogurt or sour cream. As with sweet cream milk, the source of the milk provides slight variations in taste.	The resulting buttermilk has a similar tangy flavor.	Over time, the milk thickens and develops its characteristic sour taste. Commercial manufacturers also make powdered buttermilk. They use the same process as with wet milk, then remove the liquid.

(King 1955). Apart from their ability to release biologically active peptides (Roesch and Corredig 2002), these proteins also contribute as a mixture of glycol-phospholipids in buttermilk. The phospholipids content in SCBM is around nine times greater as compared to skim milk (Table 8.2). SCBM lacks short-chain fatty acids, principally consisting of C_{16} (palmitic) and higher acids. Around 40% of fatty acids

Table 8.2 Composition and Physiochemical Properties of Sweet Cream Buttermilk and Skim Milk

CHARACTERISTIC	SWEET CREAM BUTTERMILK	SKIM MILK
Ash (%)	0.73	0.80
Fat (%)	0.60	0.09
Lactose (%)	4.84	5.25
Titratable acidity	0.13	0.15
Total proteins (%)	3.70	4.30
Total solid (%)	9.75	10.80
Phospholipids (mg)	78.60	8.50
pH	6.85	6.70

present in buttermilk are saturated by dry weight. Non-conjugated di- to penta-unsaturated acids make up the rest of the volume (Garton 1963). Additionally, the phospholipids content of buttermilk comprises cephalin, lecithin, and sphingomyelin in same amounts along with small quantities of cerebrosides. Buttermilk also varies in physical and chemical properties as compared to skim milk (Table 8.2). For instance, it has low acidity and high viscosity in comparison with skim milk. Such a difference in properties makes buttermilk suitable for numerous applications in the dairy sector, but the chemical composition of buttermilk and skim milk remain almost the same when produced under standard parameters or conditions.

8.3.1 Chemical Composition of Buttermilk

Buttermilk has emulsion and flavor-enhancing ability, which makes it a key dairy component in several food applications. The composition of sweet and cultured buttermilk is similar to skim milk. Additionally, the composition of whey buttermilk is also similar to whey. But the fat content is high in buttermilk (6%–20%) compared to skim milk (0.3%–0.4%) or whey (Sodini et al. 2006). The chemical composition of buttermilk depends largely on the amount of water added to cream. However, buttermilk is almost similar to skim milk in composition, as mentioned earlier, when produced under standard conditions (Table 8.2). The major difference between sour buttermilk and SCBM pertains to its titratable acidity. The titratable acidity is higher in sour buttermilk (>0.15%); it may be more than 1% sometimes, whereas in SCBM it lies between 0.10% and 0.15%. On the other hand, natural buttermilk has wider variations in its composition as it varies with milk quality used for the preparation of curd and the amount of water added in between the churning. Yet, on the average, it consists of total solids (4%), lactose (3%–4%), lactic acid (1.2%), protein (1.3%), and fat (0.8%).

Buttermilk contains high amounts of calcium, which contributes significantly to its health benefits. The human body requires 1,000 mg of calcium per day. Low-fat buttermilk contains around 28% calcium. Consumption of 500 ml buttermilk can fulfill the calcium requirement of the body. Riboflavin is another crucial content of buttermilk. Additionally, buttermilk also boosts protein intake.

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8.3.2 Processing and Drying of Buttermilk

SCBM can be used in dry form for various food applications. SCBM is more suitable for processing as it has higher heat stability and its constituent composition is similar to skim milk (Bratland 1972). SCBM remains similar in processes of separation, clarification, pasteurization, concentration, and drying at high temperatures. The processes of spray drying and concentration for SCBM are similar to those of skim milk powder (SMP). Spray drying of buttermilk is generally carried out at 185°C–195°C, and the drying process to concentrate the buttermilk is carried out till the 40%-50% solid in end product has been achieved. The major difference between SCBM and SMP is the concentration of total lipid and density. The total lipid consisting of phospholipids content remained high bulk in SCBM than SMP, while bulk density is found low. It is generally observed that during storage, high lipid or fat concentration can decrease the shelf life of milk powder. But the high phospholipids content present in SCBM reduces the chances of oxidation in powder.

8.4 Cultured Buttermilk

Cultured buttermilk is the sour end product obtained after fermentation of skim or partially skim milk inoculated with LAB cultures.

8.4.1 Starter Cultures Used for Cultured Buttermilk

Microorganisms that are intentionally supplemented into milk for desired fermentation to produce fermented milk products under controlled conditions are called starter cultures. The use of starters has been tremendously important as it decides the quality and nutritional value of the desired end product. But on the other hand, it has diminished the diversity of fermented dairy products (Kaur et al. 2014). Buttermilk starters contain certified organic milk and live active cultures. Large portion of these active cultures (e.g., *Lactococcus, Lactobacillus, Streptococcus,* and *Leuconostocs*) belong to LAB (Table 8.3). Additionally, non-lactic starters can also be used as a co-inoculant with LAB for the production of buttermilk.

Table 8.3 Microorganisms Used as Starter Cultures for Preparation of Buttermilk

MICROORGANISM(S)	TEMPERATURE FOR GROWTH (°C)
HETEROFERMENTATIVE	
Leu. mesenteroides	25
Lb. brevis	30
Lb. kefir	32
HOMOFERMENTATIVE	
Lb. lactis subsp. *lactis* biovar. *diacetylactis*	25
Lb. casei	30
Lb. lactis subsp. *cremoris*	30
Lb. lactis subsp. *lactis*	30
Lb. acidophilus	37
Lb. delbueckii subsp. *lactis*	40
Str. thermophilus	40
Lb. helveticus	42
Lb. delbueckii subsp. *bulgaricus*	45

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Starter cultures can be used as single, mixed, and multiple strains depending upon the type of products to be prepared for a specific purpose. The purity and activity of starter cultures define their ability to perform functions efficiently. An ideal starter culture should have some characteristics, for example, should be quick and steady in acid production, should produce a product with fine and clean lactic flavor, and should not produce any pigments, gas, off-flavor, and bitterness in the finished products.

The major role of starter cultures during the fermentation of milk are the production of lactic acid and a few other organic acids, for example, formic acid and acetic acid, changes in body and texture in final products followed by coagulation of milk, production of flavoring compounds, such as diacetyl, acetoin, and acetaldehyde, and production of antibacterial substances in the finished product.

Generally, buttermilk products (i.e., sour and cultured buttermilk) are produced by different types of starter cultures. These cultures are classified on the basis of their temperature and fermentation of glucose for growth purposes, for instance, mesophilic, thermophilic, homofermentative, and heterofermentative bacteria.

Products made by use of mesophilic lactic starter cultures (optimal temperature 30°C–40°C) may use one of the following types of microorganisms: O (homofermentative *Lactococcus lactis* subsp. *cremoris* and *Lc. lactis* subsp. *lactis*), D (microbes of O types and *Streptococcus lactis* subsp. *lactis* var. diacetylactis), L (in addition to the O type bacteria, it contains *Leuconostoc mesenteroides* subsp. *mesenteroides*), and LD (combination of *Str. lactis* subsp. *lactis* var. *diacetylactis* and *Leu. mesenteroides* subsp. *mesenteroides*).

Thermophilic bacteria work over an optimal temperature range of 50°C–60°C and digesters are usually operated as close as possible to 55°C. This offers the advantages of faster reaction rates and better pathogen-killing power/capacity as compared to mesophilic digestion, which leads to shorter retention times.

Homofermentative bacteria consume or ferment glucose that yields lactic acid as the primary end metabolite. In various dairy culture applications, *Lactococcus* ssp. is commonly used as a starter culture, when the quick lactic acid production or low pH is desirable. The sugar fermentative pathway of homofermentative bacteria is shown in Figure 8.2a.

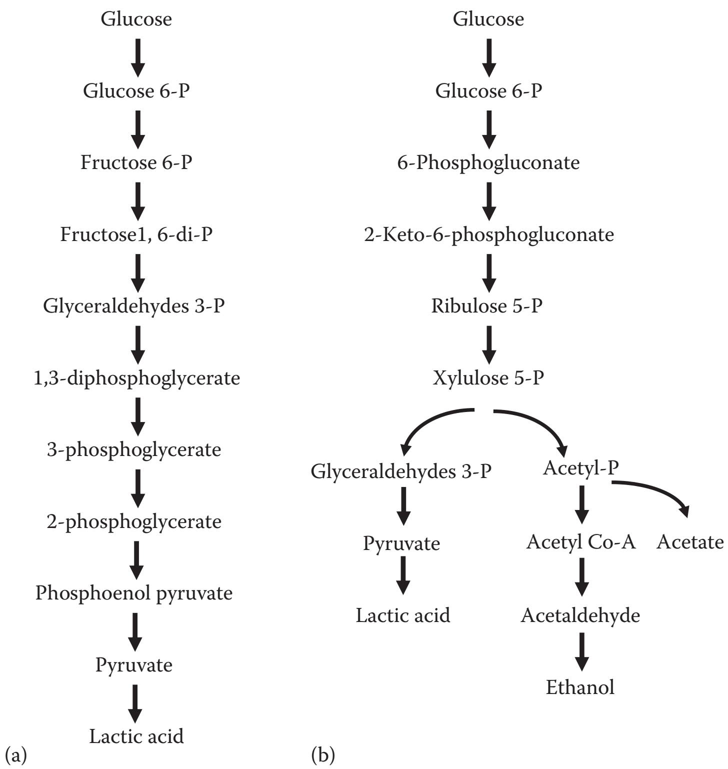

Figure 8.2 (a) Homofermentative and (b) heterofermentative pathways of lactic acid bacteria.

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Heterofermentative bacteria also consume glucose; common end products are lactic acid, ethanol, and carbon dioxide (Figure 8.2b). The common identification of heterofermentative bacteria is generally carried out by evolved gases. The application of heterofermentative LAB as starter culture in dairy products is not common. Yet, these are not rare in dairy products.

8.4.2 Production of Cultured Buttermilk

Skim or low-fat milk is used for the production of buttermilk. First, milk is pasteurized at 82°C–85°C for 2–5 min as per need. The major objective of pasteurization is killing of bacteria that are present naturally in milk and denaturing the milk protein to decrease the wheying off. Afterward, milk is allowed to cool to 22°C followed by the addition of required starter cultures, for example, *Lc. lactis* subsp. *lactis, Lc. lactis* subsp. *cremoris, Leu. citrovorum,* and *Leu. dextranicum*. These cultures are desirable candidates for imparting buttermilk's unique sour flavor by increasing acidity if butter or buttermilk is produced at an industrial or commercial level (Figure 8.3). The starter cultures *Lc. lactis* subsp. *cremoris, Leu. citrovorum,* and *Leu. dextranicum* are typically used to generate the flavor in butter, while *Lc. lactis* subsp. *lactis* is associated with the production of lactic acid, which causes the typical tangy flavor of cultured buttermilk. Hence, LAB are common and dominating groups of bacteria, which are required for fermentation of milk to produce buttermilk. Additionally, LAB are also naturally accepted and generally recognized as safe for human consumption (Aguirre and Collins 1993). During fermentation of milk, growth and metabolic activities of LAB cause a few changes in milk, which results in chemical and physical modifications in milk as shown in Table 8.4. After the fermentation, coagulum is stirred, packed, and stored at refrigerated temperatures. The production scheme of buttermilk is shown in Figures 8.1 and 8.3.

Moreover, probiotics are very popular throughout the world due to their health benefits, so adding probiotics to starter cultures or after the production of buttermilk is often carried out these days in addition to the conventional method (El-Fattah and Ibrahim 1998; Rodas et al. 2002; El-Shafei 2003).

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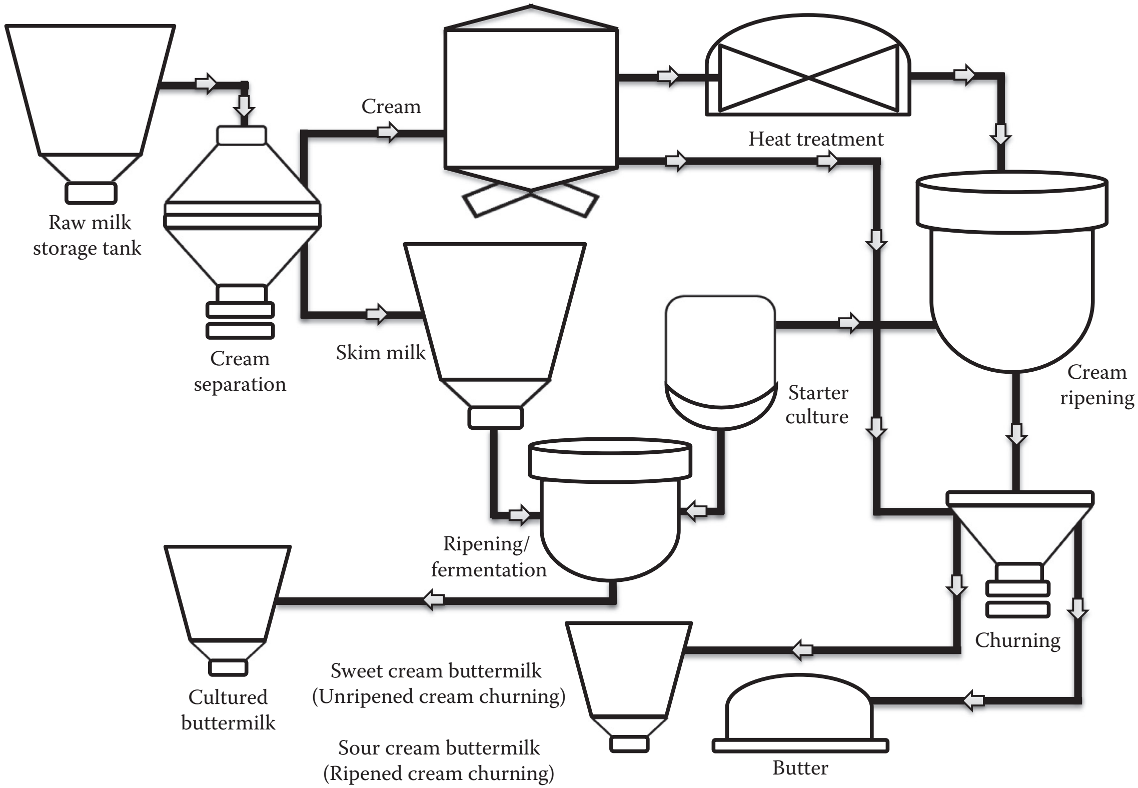

Figure 8.3 Large-scale production scheme of buttermilk.

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Table 8.4 Changes in the Constituents during Milk Fermentation

COMPONENTS	FORMULATION OF COMPONENTS
Breakdown of fat	Flavored compounds and acetic, propionic, butyric, isovaleric, caproic, caprylic, and capric acids generated due to breakdown of fats
Breakdown of protein, for example, casein	Generation of amino acids (serine, glutamic acid, proline, valine, leucine, isoleucine, and tyrosine) due to breakdown of proteins
Breakdown of vitamins, carotenoids	Simple vitamins, B_2, B_6, and B_{12}
Lactose lytic	Lactic acid, galactose, and glucose produced due to breakdown of lactose

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8.5 Uses of Buttermilk

Apart from its use for consumption purposes, buttermilk has various applications in several food product formulations, especially with reference to the fermented products. Traditional buttermilk is itself a popular drink in many countries (Patel and Gupta 2008). Yet, addition of fruit juices or fruit pulps is an attractive avenue to utilize buttermilk as well to increase the earning of the associated sector. Several types of refreshing drinks of buttermilk have been prepared using litchi, apple, banana, mango, and guava pulp (Shukla et al. 2004). Furthermore, the addition of cashew (15%) and kokum syrup (10%) has been employed to prepare flavored buttermilk (Kankhare et al. 2005; Patel and Gupta 2008). Rao and Kumar (2005) developed a spray dried buttermilk powder with mango pulp. A product with desired sensory effect was obtained when buttermilk (80%) was blended with mango pulp (20%).

Moreover, large-scale dairy plants and industries blend pure SCBM in whole milk for fluid milk supply or in skim milk for processing, that is, drying. The blending of SCBM in buffalo milk to prepare toned milk usually increases the various properties of end products such as palatability, heat stability, viscosity, and decreased curd tension (Pal and Mulay 1983; Patel and Gupta 2008). Flavor milks and beverages can also be prepared with use of SCBM. Moreover, skim milk and SCBM powder blends are commonly used for reconstitution applications.

Buttermilk can be used in many food formulations in place of SMP. Generally, buttermilk is used to enhance the texture, thickness, and reduction of fats. Several examples are discussed here. For instance,

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the thick and smooth texture of yogurt, which is a highly desirable characteristic, can be achieved by increasing total solids in the yogurt mix. Conventionally, to achieve the required total solid content, the milk is boiled till it reduces by up to two-thirds of its original volume. Boiling of milk is not regarded as a suitable approach, and hence, blending of SMP in milk is the best alternative to increase total solids. SCBM has been used as a substitute of SMP. It has been demonstrated that substitution of SMP up to 50% by buttermilk for low-fat yogurt preparation yielded the end product which was closely similar to control product (Vijayalakshmi et al. 1994). Further, addition of 4.8% SCBM in low-fat yogurt imparted a smooth soft texture (Trachoo and Mistry 1998; Patel and Gupta 2008). Moreover, the addition of SCBM also reduces syneresis in yogurt as compared to other constituents (Guinee et al. 1995). Romeih et al. (2014) added buttermilk powder with reduced fat content. The addition of buttermilk powder caused a decline in pH while it improved the functionality of the yogurt gel in terms of water-holding capacity and exhibited the most desirable organoleptic attributes. The investigation proved that buttermilk powder can be used as a valuable alternative in fat-free yogurt production with a source of extra protein.

Buttermilk also plays a potential role in cheese formulations. The process of formulation of hard cheeses, for example, Cheddar and Gouda carried out with low-fat milk as high fat content imparts soft texture to cheese body. Generally, skim milk is added to bulk milk to adjust the fat content so that hard body cheese can be obtained. In various dairy applications, SCBM has been used to replace the skim milk. Therefore, SCBM has also been used to prepare hard cheese in place of skim milk. The major problem with the supplementation of SCMB is the presence of the high fat membrane material that yields soft body cheese. However, the blending of SCBM up to some extent can result in the desirable hardness in Cheddar cheese (Joshi and Thakar 1996a, 1996b). To overcome the problem of high fat content, ultrafiltrated SCBM is generally used. The ultrafiltered SCBM supplementation is reported to give improved quality (body and texture) to cheese in comparison with the control (Mistry et al. 1996). Using the same strategy, low-fat Cheddar cheese was also produced. Interestingly, this cheese consisted of less fat (14.5%) as compared to control (15.1%), when milk was blended with 5% ultrafiltered SCBM (Raval and Mistry 1999;

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Patel and Gupta 2008). Further, ultrafiltered buttermilk was used to prepare reduced fat Mozzarella cheese (Poduval and Mistry 1999). SCBM (30%–40%) was also utilized to prepare cottage cheese by replacing whole milk; the end product was an enhanced flavored soft cheese (Shodjaodini et al. 2000). Moreover, Gokhale et al. (1999) successfully blended SCBM up to 75% to lower down the water content in processed cheese and no significant alteration was observed in cheese composition. Concentrated buttermilk (CBM) was employed for making processed cheese, and some of its physicochemical properties were also studied. The observations found that CBM can be used to make functional processed cheese and can also be supplemented as an ingredient in other dairy products (Doosh et al. 2014).

Paneer or Indian cheese is generally prepared with addition of acids (e.g., citric acid) in milk, which causes coagulum of milk; that integrated mass of milk coagulum is known as paneer. Prior to preparation of paneer, standardization of milk is required, which is commonly done with the addition of skim milk. But it has been observed that addition of SCBM in buffalo milk in place of skim milk enhanced the yield (around 1%) of paneer without causing any changes in texture and sensory properties (Pal and Garg 1989; Patel and Gupta 2008). Additionally, buttermilk (10%) has been used in place of buffalo milk for the preparation of fried paneer, which showed that the uptake of oil was high and the end product revealed soft texture compared to the control (Sharma et al. 1998). On the other hand, it was observed that up to 50% cultured buttermilk incorporation in paneer whey can result in a good quality drink. The chemical composition of blending results in around 8.31% total solids, 2.20% protein, 1.10% fat, 4.40% lactose, and 0.55 ash. This cultured buttermilk was accepted very well and its shelf life was 5 days under refrigerated conditions (Ghanshyambhai et al. 2014).

Buttermilk powder can be used along with milk for the preparation of curd. Curd or dahi (Indian curd) is prepared from milk with the addition of a mixture of starter cultures. Generally, buffalo milk is used for this preparation. Nevertheless, the addition of 1%–2% SMP with milk enhances the texture body of dahi prepared from buttermilk (Shreshtha and Gupta 1979; Patel and Gupta 2008). The higher amount of SCBM in buffalo milk yields soft body curd.

The preparation of various Indian sweets involves buttermilk and buttermilk powder. For example, chhana is unripened curd cheese

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prepared from buffalo milk and it is used for formulation of several sweets, for example, rasgulla. Sometimes, compositional changes in buffalo milk yield hard and greasy chhana, which are undesirable defects in this product. To reduce such defects, several suggestions, for instance, addition of salts (e.g., sodium citrate), dilution of milk (20%–30% water), low temperature coagulation, and homogenization, have been proposed (Rajorhia and Sen 1988; Patel and Gupta 2008). Along the same lines, the addition of SCBM (60%; on the total solid basis) buffalo milk showed acceptable preparation of chhana (Kumar 2006). Similarly, the formulation of rasgulla needs chhana prepared from cow or buffalo milk. Usually the soft body and texture of chhana is desirable for rasgulla, but buffalo milk yields hard body chhana. To overcome this, buttermilk continues to be the favorite constituent to increase the softness of chhana. It has been seen that the blending of SCBM in buffalo milk at a ratio of 60:100 with other constituents (i.e., arrowroot, maida, and semolina) produced better quality rasgulla (Kumar 2006; Patel and Gupta 2008).

Sandesh is another Indian sweet that is made from chhana. This sweet is made from cow milk chhana due to its soft body and texture (Sen and Rajorhia 1990). However, trials have been carried out with chhana prepared from buffalo milk. Similar to rasgulla, addition of SCBM in buffalo milk yields better quality sandesh (Kumar 2006). The blending ratio of SCBM and buffalo remained 60:100. Moreover, the preparation of basundi can be carried out with the help of SCBM solids in place of whole buffalo milk solids. However, the 100% replacement of buffalo milk solids with SCBM powder causes a decrease in the lactose and ash contents in end product. It also showed adverse effects on the physicochemical properties (Patel and Upadhyay 2004; Patel and Gupta 2008). Nevertheless, the preparation of basundi with 25% of SCBM yielded a good product, which shows the potential role of SCBM in the formulation of basundi.

Chakka is made from dahi prepared from buffalo milk. Basically, chakka is an intermediate product that is used to prepare shrikhand. When whey is drained from dahi, the leftover semi-solid mass is known as chakka, which is sweetened with sugar and named as shrikhand. The formulation of chakka and shrikhand has also been carried out with the supplementation of SCBM to enhance the properties of the end product. It has been reported that the addition of SCBM (50%)

imparted enhanced flavor, body, and texture, and the end product did not show any alteration in chemical composition. The addition of 15% SCBM yielded the same quality shrikhand as with buffalo skim milk (Karthikeyan et al. 1999).

The production of ice cream and other frozen desserts also involves the use of buttermilk powder. SCBM has been used as a better alternate for SMP. In a study, it has been shown that the mixture of spray dried whey and dried SCBM powder at a ratio of 50:50 yielded good quality ice cream as compared to control (Tirumalesha and Jayaprakasha 1998).

Probiotics are popular foods and their market is increasing day-by-day worldwide. The same is true for buttermilk as well. Trials on probiotic-based buttermilk successfully demonstrated the utility of this drink. The health benefits of such probiotic buttermilk have been validated in Japanese quail hens (El-Fattah and Ibrahim 1998). In this study, buttermilk fermented with *Lb. acidophilus* was fed to hens for 100 days; there was a significant decrease in low density cholesterol levels in serum and liver, whereas there was an increase observed in high density lipoproteins. In another investigation, buttermilk supplemented with *Lb. reuteri* (1%) did not show any change in composition and sensory attributes (Rodas et al. 2002). Other probiotic strains have also been used successfully for the preparation of probiotic buttermilk with potential health attributes (El-Shafei 2003).

Apart from its traditional dairy uses, buttermilk powder can be used to enhance the functional, nutritional, and organoleptic properties of bread. Büşra Madenci and Bilgiçli (2014) added buttermilk powder in leavened and unleavened flat bread dough at different levels, and the supplementation of buttermilk powder enhanced the dough properties (i.e., resistance to extension and maximum resistance and dough stability). Additionally, it also improves the protein and mineral contents with better taste and odor.

Buttermilk improves the flavor and aroma of cakes and dips. It also works as a battering agent for frying of chicken and chops of pork (Raval and Mistry 1999; Shukla et al. 2004). In the preparation of some of the Indian dishes, buttermilk is also added to initiate fermentation in raw materials of bhature, jalebi, and idli.

Moreover, it has been noticed that buttermilk powder has heat resistance ability and in combination with glucose syrup improves oxidative stability. On pH adjustment and heat treatment, buttermilk

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revealed superior encapsulating properties compared to skim milk for fish oils (Augustin et al. 2014).

8.6 Health Benefits of Buttermilk

The health benefits of buttermilk have been evidenced by many studies. Clinical trials studying the effects of buttermilk on various diseases (e.g., cholesterol reduction, blood pressure reduction, antiviral effects, and anticancer) have showed positive effects.

Lactose intolerance or inability to digest lactose in adults is common worldwide. People with lactose intolerance are not able to consume whole milk as consumption may cause abdominal pain, bloating and diarrhea, and flatulence. Inability to digest lactose in adults occurs due to the absence or presence of lactase in low levels in small intestine. However, the population suffering from lactose intolerance can consume buttermilk as an alternative for whole milk. The microflora present in buttermilk have the ability to metabolize lactose (Figure 8.2). The metabolic activity of microbes converts lactose in lactic acid, which is easy to digest. Additionally, buttermilk also plays an assistive role in the removal of undesired stomach acid (which causes indigestion and heartburn) by creating a layer on the lining of the stomach and moving the acid through esophagus.

Moreover, the interaction of buttermilk with resveratrol has been shown to be helpful in the delivery of this component (Ye et al. 2013). In fact, the binding ability of whole buttermilk with resveratrol or a complex formulation enhances the aqueous solubility of resveratrol, which is quite helpful in the delivery of this component in system via the natural route. Further, it has also been suggested that hydrolyzed proteins of buttermilk are a rich source of natural antioxidants (Conway et al. 2013b).

Buttermilk edible films are also nowadays used, and the effect of incorporating different ratios of both non-heated and heated (95°C) buttermilk to corn starch films was analyzed in terms of its structural, mechanical, barrier, optical, and bioactive properties. It was observed that only films formulated with heated buttermilk exhibited antioxidant activity, probably due to the release of the antioxidant peptides during thermal treatment of proteins (Moreno et al. 2014).

Turmeric is good source of phenolic components, for example, curcuminoids (curcumin, demethoxycurcumin, and bisdemethoxycurcumin),

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which have anti-inflammatory and antioxidant activities and other properties of clinical importance. Sometimes, poor stability of these phenolic components in foodstuffs discourages their potential health attributes. However, it has been seen that buttermilk has a good capability to stabilize these phenolic components compared to buffers. So, buttermilk can be used to deliver these turmeric components in the system to impart health benefits (Fu et al. 2014).

Further, it has been observed that consumption of cultured buttermilk can decrease the chances of bladder cancer (Larsson et al. 2008). It has also been suggested that buttermilk intake can reduce cholesterol levels by inhibiting the assimilation of cholesterol in the intestinal tract (Conway et al. 2013a).

Consumption of buttermilk can reduce blood pressure in moderately hypercholesterolemic individuals. It was seen that arterial blood pressure and systolic blood pressure get reduced with continous buttermilk consumption. The concentration of angiotensin-I converting enzyme also decreased in plasma, while levels of angiotensin-II and aldosterone remained unchanged (Conwey et al 2014a). In another study, Fuller et al. (2013) showed anti-rotavirus activity using the milk fat globule membrane obtained from buttermilk.

Buttermilk is also quite helpful in losing or controlling weight as it is low in calories when compared with whole milk. It is estimated that buttermilk has only 50% of the calories and fat found in milk. The routine consumption of buttermilk leads to a decrease in weight. Individuals can replace whole milk with buttermilk to gain health attributes (Conway et al. 2014b). Although the health benefits of fermented milk products are great, research is still going on to investigate the health benefits of products that are either indigenous or commercial. In this regard, buttermilk is one of the most important cultured products. The cultured or fermented products also have additional advantages as compared to the non-fermented products because fermentation itself imparts the nutritional, therapeutic, functional, and other qualities to a particular product, which is after all the final requirement. Nowadays, many human problems related to health are solved by these cultured products along with cultured buttermilk, discussed above. Hence, cultured buttermilk can be used as a promising key to overcome some health-related problems.

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8.7 Summary

Buttermilk is a traditional by-product and famous as a dairy drink, which is used in various formulations. Yet this product is not well explored for different roles in dairy and other associated food sectors at commercial level. Many workers are investigating to find out the role of buttermilk as health foods; for example, the functions of buttermilk phospholipids have been related with many health benefits. However, the validation of buttermilk benefits (i.e., anticancerous and anticholestrolic activities) is needed in detail. To enhance buttermilk quality and health attributes, the appropriate selection of microbes, production strategies, and suitable storage protocols have to be adopted or developed. Moreover, innovations in buttermilk, for example, probiotic buttermilk, are ongoing; yet, more concerted efforts are required to prove the potential of this dairy product.

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