16 Milk and dairy products

I Introduction

The purpose of this chapter is to give the reader an appreciation of the complex relationship between microorganisms and dairy products. Much of the technology of dairy processing is long established and is reviewed in detail elsewhere (Varnam and Sutherland, 1994; Spreeer, 1998; Robinson, 2002; Tetra Pak, 2003). The microbiology of butter is discussed in Chapter 11. This chapter discusses milk (raw or heat-treated) for human consumption, concentrated and dried milks, and fermented milks.

A Definitions

“Milk” is the product of normal secretion of the mammary gland of mammals. This chapter focuses on milk obtained from cows, with milk obtained from other animals, including sheep, goats, buffaloes, camels, or horses, mentioned where appropriate.

“Milk for direct consumption” is intended for sale directly to the consumer. This includes raw milk, where legally permitted, and processed milks. For microbiological considerations, however, any milk that has not been heated to pasteurization temperatures or higher is considered raw. Other fluid milks for direct consumption are pasteurized, sterilized, ultra-high-temperature (UHT)-treated and include whole milk, low-fat milk, skim milk, and flavored milks.

“Cream” is the fat-rich part of milk that is separated by skimming or by other techniques. According to their fat content (~10–55%), different types of cream can be differentiated by classification depending on local regulations.

“Concentrated milks” are those from which part of the water has been removed, e.g. concentrated milk, evaporated milk, or sweetened condensed milk. These products may be reconstituted or used in the condensed form. Standards for this category of products have been established by Codex Alimentarius (1999a,b).

“Dried dairy products” normally contain <5% residual moisture and include dried whole milk, skim milk or non-fat dry milk (NFDM), cream, buttermilk, cheese, and whey. Low heat and instantized milks are special forms of dried milks. Standards for this category of products have been established by Codex Alimentarius (1999c).

“Cultured or fermented milks” are milk products intended for consumption after fermentation by lactic acid bacteria or by fungi and lactic acid bacteria.

“Cheese” is the product of casein coagulation in the milk, followed by separation and removal of the whey from the curd. Casein coagulation in the milk is achieved by addition of rennet (the majority of cheeses), or by addition of acids (Harzer cheese), or by a combination of both coagulation techniques (e.g. Speisequark). Standards for this category of products have been established by Codex Alimentarius (2001, 2003).

“Whey cheeses” are made by coagulation of whey proteins through heat treatment of whey and subsequent ripening by fermenting starter cultures. The formation of curd and subsequent coagulation are brought about by acidification typically using fermenting starter cultures or by adding acids directly to the milk. Apart from certain fresh cheese, curd is then textured, salted, formed, pressed, and finally ripened. Cheese varieties included fresh, soft, semi-soft, and hard, as well as processed and blended cheeses. Standards for this category of products have been established by Codex Alimentarius (1999d).
“Ice cream and ice milk” are formulated milk products intended for consumption in the frozen or partially frozen state.

A detailed listing of all definitions used for dairy products can be found in the “General Standard for the Use of Dairy Terms” issued by Codex Alimentarius (1999e).

B Importance of microorganisms and other important properties

Milk as synthesized in the milk-producing glands of various mammals is designed by nature to meet specifically the nutritional needs of the suckling calves. “Average” cow milk is composed of approximately 87.3% water, 4.2% fat, 4.6% lactose, 3.25% protein, and 0.65% mineral substances (Walstra and Jenness, 1984; Nickerson, 1995; Schlimme and Buchheim 1999; Walstra et al., 1999). However, the composition of milk varies widely among, and even within, breeds of cows. Milk composition also depends on feeding practices, age of the animals, and phase of lactation (Toppino et al., 2001). The secretion of the first (usually five) day post-parturition is called colostrum, which is extremely rich in protein (up to 27%) and particularly in immunoglobulins, enabling the newborn ruminant to resist various infections (Barrington and Parish, 2001). Colostrum is rarely used as human food and then only in certain regions. Milk from other animals, for example buffaloes, sheep, horses, and camels, differ considerably from cows’ milk with respect to composition and physical properties.

Metabolic disorders in milk-producing animals, and errors in handling during milking, handling, transport, and storage may cause defects in the sensory, chemical, and physical qualities of raw milk. Inflammatory changes of the mammary gland including sub-clinical mastitis lead to changes in milk composition and technological suitability (e.g. lower heat stability of whey protein, reduced yield in cheese production, off-flavor of milk products). Residues of veterinary drugs used in animal husbandry are undesirable and can impact the production of fermented dairy products and cheese. They may also be illegal and some may even pose potential health hazards to the consumer.

Microorganisms are important in milk and dairy products for three principal reasons:

- Pathogens or their toxins may constitute health hazards.
- Spoilage microorganisms or their metabolites may cause spoilage.
- Lactic acid bacteria and others may contribute in the preservation of milk and in the production of desirable flavor and physical characteristics.

To minimize milk-borne food poisoning and spoilage problems, routes of contamination of detrimental microorganisms and factors influencing their destruction and proliferation must be known and understood. Furthermore, new products and new processing technologies must be evaluated to ensure their safety and effectiveness.

Statistics of food-borne disease outbreaks show that milk and milk products contribute to a lesser extent to food-borne illness than other foods of animal origin. A survey of US food-borne diseases between 1990 and 2001, in which both the food and the etiological agent were identified, listed a total of 1 589 outbreaks involving 73 425 cases. Of these, 65 outbreaks (2 866 cases) were linked to dairy products (De Buyser et al., 2001). The European Surveillance Programme for Control of Food-borne Infections and Intoxications reports that 7.8% of investigated outbreaks where the food was known were traced to milk and milk products and 0.6% to cheeses. The major cause for milk-borne disease is consumption of raw milk and recontaminated processed and mixed dairy products such as cream fillings (FAO/WHO Collaborating Centre for Research and Training in Food Hygiene and Zoonoses, Berlin, 2001). Gillespie et al. (2003) reviewed 27 milk-borne outbreaks between 1992 and 2000 in England and Wales representing 2% of all food-borne outbreaks. They highlighted the importance of VTEC O157 and the continued role of unpasteurized milk in human disease.