

MILK AND MILK PRODUCTS

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Summary

Although, in the broadest sense, milk is defined as the normal secretion of the mammary gland of mammals, the term milk is generally used for cow's milk, because, in the majority of countries, mainly cow's milk is produced. All other milk is qualified by some adjective such as human milk, buffalo milk, and so on. In some countries, sheep and goat milk are also used extensively, and in Asia buffalo milk may be as important as cow's milk. Dairy products may be defined as all foods and other commodities derived from milk.

About 75% of the milk produced in animal husbandry is used in its liquid form, and most consumer milk is pasteurized. Usually, milk is also homogenized.

The main factors in the quality evaluation of milk are:

1. good sensory properties (absence of off-flavors, normal color)
2. adequate microbiological status (good keeping quality) including:
 - absence of pathogens
 - absence of post-pasteurization contamination
 - absence of the consequences of mastitis
 - standard chemical composition (protein, fat, carbohydrates, vitamins, and minerals)
 - absence of any chemical contaminants (pesticide residue, veterinary drug residue, mycotoxin residue or its metabolites).

Adequate microbiological status is an important quality index of every dairy product. The requirements concerning sensory properties are also included in quality evaluation. Standards of composition for dairy products include (similar to milk) the main nutrients and, depending on the type of dairy product, some other components (e.g., the salt content in cheese).

Milk and dairy products are more rigidly controlled by legislation and standards than any other class of food. This concerns primarily microbiological control, but preservatives are either absolutely forbidden or rigidly controlled, and specific rules regulate the storage and distribution of dairy products.

1. Introduction

About 75% of milk produced in animal husbandry is used as liquid, and the overwhelming amount of this is pasteurized. Although the direct consumption of raw milk eliminates the nutrient losses connected with the heat treatment of milk during pasteurization, the amount of commercially distributed raw milk is low for safety reasons.

A great variety of dairy products are known worldwide. In the framework of this chapter it is not possible to give a full overview of quality indices for these products. Thus, primarily, the quality-determining factors of raw and pasteurized milks will be treated, and only for some dairy products.

Because of the specific status of milk and dairy products with regard to public health, and the importance of microbiology in the manufacture of dairy products, mostly the microbiological and safety aspects of quality evaluation and the sensory properties will be discussed. Chemical composition and its role will be treated only briefly.

2. Quality of Raw Milk

The first step in the quality control system of milk is the quality evaluation of raw, untreated milk. It is universally accepted that a good quality raw milk supply is essential for the production of different, high quality dairy products. The term quality in relation to raw milk includes the following characteristics:

- microbial behavior of milk (keeping quality)

- safety (freedom from pathogenic organisms and other contaminants that may constitute health hazards)
- sensory properties (freedom from unusual odor, taste, color, and so on)
- purity (freedom from any extraneous matter)
- chemical composition (normal content of nutrients and minor components)
- physical properties (structure, viscosity, density, size of fat globules)

2.6. Microbial Aspects of Raw Milk

Each type of food has its own structure, chemical composition, moisture content, acidity, and oxygen tension. These factors decide the predominant microflora of the normal product, the vulnerability to certain microorganisms, and the potential danger of the food to humans.

The numbers of microorganisms in milk are always changing, unless the milk is kept at low temperatures, or has been sterilized. To understand potential changes concerning the microbiological status of milk, it should be mentioned that under optimum conditions at 37 °C, one bacterial cell can become two in 20 min, and 1 million in about 7 h. The rate of proliferation is usually much slower than this, but the population may easily increase 1000-fold overnight in warm weather. A rigid standard on count is therefore unjustifiable, and it is preferable to think in terms of satisfactory, doubtful, and unsatisfactory. Although there are significant differences concerning microbiological standards of freshly produced raw milk, it may be stated that raw milk of satisfactory quality should contain less than 10 000 microbial cells per ml, and a total count of more than 50 000 per ml means that the raw milk is unsatisfactory.

There is always some deterioration between production and receipt at the depot, and this is often considerable in summer. The importance of a bacteriologically bad supply is much greater than that of a chemically poor supply. Thus, 1% of median fat or protein content being below average is of negligible significance. However, 1% of a batch of milk having a total count of 1 000 000 microbial cells per ml could ruin the whole 200 000 l received in a dairy factory in one day.

The prerequisite of the production of milk of satisfactory microbiological quality is good hygienic practices in the cow barn.

It should be noted that only count standards are given for farm milk as produced. At a dairy factory, generally the dye reduction test (resazurin test, methylene blue test) or titratable acidity (lactic acid) measuring is used for quality control.

2.7. Safety of Raw Milk

Among the potential contaminants influencing the safety of raw milk, the biological (microbial) and chemical contaminants are the most important. As mentioned previously, a high total microorganism count makes milk unsatisfactory for human consumption. Among the common microbial problems concerning the safety of raw milk, mastitis should be mentioned first. Mastitis is a common inflammatory condition of the udder, and exists in two forms. In clinical mastitis, blood is present, or the milk is

watery or discolored, and such milk obviously should not be mixed with the rest, and should be rejected by the dairy factory. In subclinical mastitis, no visible signs are present. Bulk milk always contains a small proportion of milk from cows suffering from sub-clinical mastitis, but the effect on the composition and behavior of the bulk milk is small. The treatment of cows for mastitis is the concern of veterinarians, and human health aspects of milk are the concern of the local health officer. Good hygienic practice in cow barns, treatment with antibiotics, care in handling and treating the tracts, and the correct operation of milking machines are factors of outstanding importance.

For quality control of raw milk, a microscopic examination of the centrifugal deposit using the Gram stain is quick and convenient for a large number of samples, especially if an automated method is available. This test gives the number of the cells and the number and types of bacteria (staphylococci, coliforms, yeast, molds, and so on).

Among potential chemical contaminants, the presence of detergents and sterilants may occur only at mismanaged farms, as a consequence of failure to rinse equipment and reservoirs. Inclusion of milk too soon after treatment of a cow for mastitis may result in the presence of antibiotic residues in raw milk. Feeding cows with silage or compound feed contaminated with pesticides or mycotoxins may cause the residue of these compounds to be present in milk. Residues may be detected by sophisticated analytical techniques, primarily by chromatographic procedures (see *Food Quality and Assurance*).

Concerning the safety of milk, lactose intolerance should be also mentioned. A rather high percentage of African and Asian populations produce less intestinal beta-galactosidase (lactase, an enzyme needed for digestion of this sugar component of milk), than do Europeans or North Americans. Consequently, those populations encounter lactose malabsorption more frequently. The symptoms of lactose malabsorption are diarrhea, bloating, and abdominal cramps. For consumers suffering from lactose intolerance, the lactose of milk is hydrolyzed before consumption using an immobilized lactase preparation in the dairy factory. Cultured milk products, such as yoghurt, where the lactose is fermented to lactic acid, may be freely consumed by lactose-intolerant people.

2.8. Organoleptic Properties of Raw Milk

When drawn from a healthy udder, cow's milk has a characteristic flavor (odor and taste). This is a complex property associated with trace amounts of many substances, including carbon dioxide, ketones, aldehydes, fatty acids, sulfhydryl compounds, and so on. The flavor and attractiveness of milk is controlled by smoothness, "body" on the tongue, and by color. Skim milk tastes thinner than whole milk, and is in general less attractive. Moreover, the yellow color comes from fat and so is absent in skim milk.

Taints or off-flavors in milk are usually of microbiological origin, but occasionally other types are found. Some types of off-flavors will be briefly discussed.

Rancid or soapy flavors. Free fatty acids in milk, whether derived by naturally occurring lipases of milk or by the activity of microorganisms, are important from the point of view of flavor, giving rise to rancid or soapy taints.

Oxidized, metallic flavors. Oxidized, metallic, and fishy flavors have certain features in common. They tend to occur in milk of low bacterial count contaminated with copper and/or iron and exposed to light. The naturally present concentrations of iron and copper in milk are small (0.1 ppm to 0.5 ppm), and being bound to proteins are not active catalysts of oxidation. Higher concentrations (more than 1 ppm) are the result of contamination. The compounds responsible for oxidized flavor appear to be unconjugated, unsaturated carbonyl compounds formed by oxidation of milk lipids.

Weed taints of milk. Taints due to weeds, certain crops, and silage are well-recognized hazards of milk production, as the odoriferous substances may pass into the milk, and such feeds should be given only immediately after milking. Weed taints are often due to particular chemical compounds in the milk. For example, bitter cress (*Coronopus didymus*) can give a burning taste and a sharp odor in milk, which is due to benzylthiocyanate. As little as 0.16 ppm produces a detectable taint. When the taint substance is soluble in fat, as most are, it cannot be removed from the cream or butter, and so such taints are a serious menace to the industry.

Absorbed flavors. The natural fat of milk and cream, due to the large surface of fat emulsion and the strongly adsorbing protein-lipid layer on the globules, is one of the most effective materials known for absorbing odors. Extreme care must therefore be taken to avoid absorption of unpleasant odors by milk and its products.

Concerning identification of the cause of taint in raw milk, it may be mentioned that if the taint is strong directly after milking, the cause is probably in the feed, or the accidental addition of detergents, sterilants, and so on, to the milk. If the taint becomes progressively worse over the 24 h before bottling, the cause is probably bacterial or enzymatic and only rarely chemical (e.g., oxidation catalyzed by copper). Further microbiological investigation may give more information about types of contaminating bacteria.

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Biographical Sketch

Radomir Lásztity, D.Sc., Professor of the Department of Biochemistry and Food Technology at Budapest University of Technology and Economics, was born in 1929 in Deszk, Hungary, and completed his studies in 1951 at the Faculty of Chemical Engineering of the Technical University of Budapest. Dr. Lásztity received his M.Sc. degree in Chemical Engineering in 1951 and his D.Sc. degree in Chemical Science in 1968.

Dr. Lásztity is honorary president of ICC (International Association for Cereal Science and Technology). He was Chairman of the Codex Committee on Methods of Analysis and Sampling of the FAO/WHO Food Standard Program in the period 1975–1988. Dr. Lásztity is a member of the Food Division of the Federation of European Chemical Societies, and a member of the editorial boards of several international scientific journals. He was Vice-Rector of the Technical University from 1970 to 1976.

Among other awards, he has received the Bailey and Schweitzer Medal of the ICC, the State Prize of the Hungarian Republic, and the Golden Medal of the Czech Academy of Sciences.

Dr. Lásztity's main research activities are the chemistry and biochemistry of food proteins, food analysis, and food control. The results of his research work were published in more than 700 papers in foreign and Hungarian journals. He is the author of more than 20 books and textbooks (among them: *Chemistry of Cereal Proteins*, First Edition and Second Edition, in 1984 and 1996, respectively; *Amino Acid Composition and Biological Value of Cereal Proteins*, 1985; *Use of Yeast Biomass in Food Production*, 1991; *Gluten Proteins*, 1987; and *Cereal Chemistry*, 1999.)