

Lesson 3: Milk Processing

Quality Grades

In most states, milk is classified as Grade A raw milk, manufacturing grade, or reject. Some areas of the country classify milk as Grade A and B or C. Grade A milk must be produced in facilities that meet high standards of sanitation defined by the state health department. Grade A milk is either raw or pasteurized and is intended for fluid milk consumption or in some places for ice cream. The standard plate count of aerobic microorganisms must not exceed 100,000 or 20,000 per ml of raw or pasteurized milk, respectively. It must be pasteurized, come from a sanitary dairy, and be cooled to below 40°F. Milk producers and their milk quality are closely monitored by inspectors.

Manufacturing grade, or in some states Grade B or C, milk is produced under less stringent conditions and is used to make cheeses, butter, and dried milk.

Reject milk does not meet minimum standards for human consumption. If rejected, no grade is assigned. Milk is not easily moved from grade to grade because facilities and practices differ.

Major Milk Products

Raw milk can be processed into fluid milk, fermented milks, cream, butter, canned milks, dried milks, cheeses, and ice cream.

Fluid milk can be whole milk, low-fat milk, nonfat milk (skim milk), and chocolate milk. Fluid milk must be made from Grade A milk only. Whole milk contains at least 3.25 percent fat. Low-fat milk can be 2 percent, 1.5 percent, 1 percent, or 0.5 percent fat. Nonfat milk contains less than 0.5 percent fat. Chocolate milk is a major product of fluid milk and may be made in any of the fat percentages listed above. Chocolate milk has liquid chocolate or cocoa and sugar added.

Any fluid milk product can be made from milk, low-fat milk, or nonfat milk and must be so labeled. For example, cultured buttermilk is made from milk (at least 3.25 percent milk fat), low-fat milk (0.5 to 2 percent milk fat), or nonfat milk (less than 0.5 percent milk fat).

Fermented milks or those that have been cultured with specific bacteria include cultured buttermilk, yogurt, and acidophilus milk. Fermented milk must be made from Grade A milk. Cultured buttermilk is skim, low-fat or whole milk that has been pasteurized, inoculated with a lactic acid-producing bacterium, and held at 72°F. Yogurt is fermented whole, low-fat or skim milk. It is fermented by *Streptococcus thermophilus* and *Lactobacillus bulgaricus*. These microorganisms convert lactose to

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lactic acid which reduces the pH. The lowered pH reduces the solubility of casein which results in the characteristic coagulum.

Acidophilus milk is a product designed for consumers who are lactose intolerant. Much of the lactose in milk is digested by the *Lactobacillus acidophilus* bacterium; furthermore, this bacterium is able to stick to and live in the human intestine.

Creams consist of cream, half-and-half, coffee cream, whipping cream, heavy whipping cream, and sour cream. Creams must be made from Grade A milk only. Cream consists of 18 percent milk fat. Half-and-half consists of equal parts of whole milk and cream. Cream contains 18 percent and milk contains 3.25 percent milk fat, so combining them in a 1:1 ratio produces half- and-half testing $[(18+3.25) \div 2 = 10.625$ percent fat]. This number is rounded to the nearest 0.5 percent for regulatory purposes. Whipping cream and heavy whipping cream contain at least 30 percent and 36 percent milk fat, respectively. Sour cream is pasteurized cream that has been inoculated with a lactic acid-forming and flavor-producing bacteria and incubated for a controlled length of time.

Butter is a water-in-oil emulsion made by churning cream.

Canned milks have reduced water content due to evaporation. The two types of canned milk are evaporated milk and sweetened condensed milk. Evaporated milk has had 60 percent of the water removed. The resulting product is 7.5 percent milk fat and at least 25 percent milk solids. In comparison, whole milk is 3.25 percent milk fat and 12-14 percent milk solids. The evaporated milk is homogenized before being placed in a can and is then sterilized. When evaporated milk is sterilized, the casein-whey protein complex tends to gel. The additive carrageenan is used to promote a smooth texture.

Sweetened condensed milk also has had more than half of its water removed. It differs from evaporated milk in that sucrose or glucose has been added. The added sugar serves as an antimicrobial agent, increases the viscosity of the milk, and promotes browning during heating. It also contributes toward a grainy texture. The caramel flavor is a result of heating the sweetened condensed milk during processing. Many desserts contain sweetened condensed milk.

Another major milk product is dried milk. The water content is reduced until the milk is a powder that can be stored in airtight containers at a cool temperature for long periods of time. Dried milk is usually nonfat dried milk. Nonfat dry milk is a major product made from skim milk. Much of the cream separated to make skim milk is used to make butter.

Cheese is made from pasteurized milk that has been inoculated with lactic acid-producing microorganisms (i.e. *Lactococcus lactis*). The milk sugar (lactose) is converted

to lactic acid which reduces the pH from 6.7 to 4.6. At this isoelectric point, casein clabbers (forms a soft curd). The curd is then cut, which releases the whey from the gel. To make coagulum with a higher pH the enzyme rennin is then added to the milk. Rennet splits the casein molecule into a hydrophilic glycopeptide and a hydrophobic molecule. The hydrophilic glycopeptide is removed and curd develops. The curd is cut and cooked to remove whey; then it is salted, shaped, and ripened.

A variety of textures, odors, and flavors result from ripening. Flavors result from chemical changes in the fats and proteins. Microorganisms are often added to promote these chemical changes. An example of this is in the production of Roquefort cheese. A blue mold, *Penicillium roquefortii*, is added to split certain fat molecules. Processed cheese is a combination of fresh and ripened natural cheeses with an emulsifier. The mixture is worked and cooked. Most processed cheese has a moisture level around 41 percent. Processed cheese spread has about a 45 percent moisture level.

Ice cream is a major milk product. It is a frozen mixture of cream, nonfat milk solids, sweeteners and flavorings into which air has been stirred. Ice cream must contain 10 percent milk fat, 20 percent milk solids, and no more than 0.5 percent stabilizer and 0.2 percent emulsifier. When sugar is added, the freezing and melting points decrease. Frozen custard is made by the addition of egg yolk solids to the ice cream mixture before freezing. Ice cream is labeled with descriptors when it contains less than 10 percent milk fat. These and their milk fat contents are as follows: reduced fat, 7.5 percent; light, 50 percent less fat; low fat, 3 grams of fat; fat free, less than .5 grams of fat. Sherbet contains 2-5 percent milk solids and 1-2 percent fat. In imitation ice creams part or all of the milk components are replaced with nondairy ingredients.

Milk By-Products

As raw milk is processed into a variety of major products, there are some by-products that result which are quite useful. Buttermilk is the fluid removed from churning cream into butter. Most of it is dried for use in the baking industry. A by-product of cheese making, whey, is a liquid containing lactose, serum proteins, minerals, and vitamins. It is an important component in certain livestock feeds, but much of it is being used in human food today. Whey protein concentrate and isolate are two major forms of whey used in foods.

Taste and Composition Factors

The taste of milk and its composition are directly related to production, handling, processing practices, and breeding. Milk may be adulterated by several different factors. Antibiotics can inhibit the growth of bacterial cultures.

Pesticides and radionuclides don't affect milk taste and only minutely change composition. Pesticides in milk can be detected by qualitative and quantitative analysis

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using chromatography. Radionuclides may contaminate milk but this usually occurs only when tests of nuclear weapons are done above ground or when an accident at a nuclear reactor releases radioactive elements. Examples of the contaminants include iodine 131, strontium 90, and barium 140.

A high somatic cell (white blood cells) count, points towards an infection in the cows udder, probably mastitis. The California Mastitis Test is used to detect high somatic cell counts in milk taken directly from the cow. A freezing point test checks for added water. Foreign material, or sediment, may contaminate the milk via the cow, equipment, or environment. A sediment test is conducted on raw milk to determine the amount of sediment.

Flavor is influenced by the age of the milk, the facilities used to process it, the temperature of the milk and rate of cooling, and certain offensive feeds in the cow's diet. The amount of milk fat also changes the milk's flavor and consistency. Facilities are unlikely to affect flavor or composition in today's milking operations.

The species and breed of animal makes a difference in milk's taste and composition. (Table 3.1). There is also a range of difference based on the animals' age, stage of lactation, season of year, feed, time of milking, physiological condition of cow (i.e. calm or excited), and length of time between milkings.

Table 3.1 - Typical Composition of the Milks of Cows

Breed	Percent in Milk				
	Water	Fat	Protein	Lactose	Ash
Guernsey	85.35	5.05	3.90	4.96	0.74
Jersey	85.47	5.05	3.78	5.00	0.70
Ayrshire	86.97	4.03	3.51	4.81	0.68
Brown Swiss	86.87	3.85	3.48	5.08	0.72
Shorthorn	87.43	3.63	3.32	4.89	0.73
Holstein	87.72	3.41	3.32	4.87	0.68

The greatest single factor governing the composition of milk is the breed of cow from which it was produced.

Summary

Milk is quality graded based on the facilities of the producer, its bacteria and somatic cell counts, and care taken in production and processing. Milk is graded as grade A, manufacturing grade, or reject milk. The quality grade determines eligibility for use in fluid products. Milk can be processed into fluid milk, fermented milks, creams, butter, canned milks, dried milks, cheeses, and ice cream. Buttermilk and whey are important milk processing by-products. The taste and composition of milk is determined by several factors. The most important factor in composition is the breed of cow from which the milk was produced.

Credit

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