PROPERTIES AND COMPOSITION OF MILK PRODUCTS

by

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Properties and Composition of Milk Products*

INTRODUCTION

Raw milk is a unique agricultural commodity. It contains emulsified globular lipids and colloidally-dispersed proteins that may be easily modified, concentrated, or separated in relatively pure form from lactose and various salts that are in true solution. With these physical-chemical properties, an array of milk products and dairy-derived functional food ingredients has been developed and manufactured. Some, mentioned in the first chapter, like cheese, butter, and certain fermented dairy foods, were developed in antiquity. Other diary foods like nonfat dry milk, ice cream, casein, and whey derivatives are relatively recent products of science and technology. This chapter describes and explains the composition of traditional milk products as well as some of the more recently developed or modified milk products designed to be competitive in the modern food industry.

Although many newly developed dairy products have been reported from research laboratories around the world, only those currently on the market are discussed here. For additional information on recent world-wide developments in the manufacture of new and modified dairy products, see the proceedings of the 20th International Dairy Congress (1978).

*Revised from Chapter 2 in the second edition by R. E. Hargrove and J. A. Alford (1974).

Milk products are manufactured from fluid milk by various methods: 1. By removing an appreciable amount of water, as in condensed and evaporated milk or dry milk powder. 2. By removing one or more natural constituents and concentrating the remaining material, as in butter and nonfat dry milk. 3. By altering the natural constitutents by bacterial or chemical action, as in cheese or fermented foods. In most cheeses the casein/fat ratio remains essentially the same in the cheese as that of milk while lactose disappears. 4. By blending milk and milk products with sugar, flavoring agents, and stabilizers to make ice cream and ice milk.

Traditional dairy products are fairly common throughout the world and their compositions are basically the same from one country to another. International standards proposed by the International Dairy Federation, the Food and Agriculture Organization of the United Nations, and World Health Organization have done much to standardize dairy products throughout the world. Some dairy foods, certain fermented milks and cheeses, are indigenous to particular countries or areas of the world. In the United States the composition of most diary products is regulated by federal and state standards (USDA. 1981B). In instances where there are no federal standards regulating interstate commerce for a particular product, state standards prevail. Typical chemical

analyses of dairy foods are given in Tables 2.2 through 2.8.

Table 2.1 shows the approximate percentages of the total milk supply used for various products in the United States and nine major milk producing countries. In such countries as New Zealand and Ireland, where per capita production of milk is high, the major share of milk goes into storable manufactured products like butter, cheese, and nonfat dry milk. Where per capita production is low like in United States and United Kingdom, greater amounts are used as fluid milk and creams.

FLUID MILKS AND CREAMS

Milk and milk products purchased by the consumer in liquid or semi-liquid form generally are classified as fluid milk or cream. Fluid milks include all of the plain milk products with fat contents varying from whole to skim milk as well as flavored and fermented milks. Creams include products varying in fat content from half and half to heavy whipping cream to fermented sour cream. Products from each category are described briefly with information on each composition.

In the United States, composition of fluid milk products and cream is regulated primarily by state and federal standards. See Table 2.2 for these legal standards. Sanitary quality is regulated by sanitary codes established by states and local health

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Table 2.1

Production and per capita consumption of fluid milk, cheese, butter, and nonfat dry milk in selected countries (Milk Industry Foundation, Milk Facts 1981; USDA. 1981D).

	Production of milk and milk products						Per capita consumption[1]			
	Billons of pounds	Per capita	Fluid[1,2,4] Milk %	Cheese[3,4] %	Butter[3,4] %	Nonfat[3,4] dry milk %	Fluid milk lbs.	Cheese lbs.	Butter lbs.	Nonfat dry milk lbs.
United States	128.4	581	39.7	30.7	18.8	9.9	231	17.1	4.1	3.0
Canada	17.5	716	39.4	22.5	27.3	15.6	282	16.5	9.7	4.5
Denmark	11.3	2200	10.6	41.4	47.5	8.0	233	20.2	23.6	13.3
Finland	7.2	1513	35.5	21.3	47.3	20.1	538	16.6	27.7	24.9
France	74.1	1443	16.8	26.7	31.0	20.0	243	38.6	21.1	26.3
Ireland	10.6	3207	15.4	10.1	52.9	32.1	494	6.0	26.7	6.7
Netherlands	26.0	1847	17.3	37.6	37.3	14.3	319	27.4	10.9	39.1
New Zealand	15.1	4652	9.6	15.5	81.7	27.7	447	19.1	29.3	2.7
United Kingdom	35.7	639	47.4	14.3	23.1	16.4	303	12.9	14.3	5.3
Soviet Union	199.5	751	27.5	7.6	31.6	4.1	207	5.8	11.7	3.1

[1] Fluid milk and cream based upon whole milk equivalent (fat solids basis)

[2] % fluid milk calculated from per capita consumption/per capita production X 100 (USDA. 1981D).

[3] Calculated from metric tons produced and converted to pounds milk equivalent with factors 21.2 pounds of milk/pound of butter, 10 pounds/pound of cheese and 11 pounds/pound of NFDM. Percent of production calculated by dividing total pounds of milk product by total pounds of milk produced X 100 (Milk Industry Foundation, Milk Facts 1981).

[4] Production figures do not total 100% because other milk products (frozen desserts, condensed, etc.) are not included, and there is an overlap of milk used for both butter and nonfat dry milk, also whey butter from cheese.

departments. The basis for most U.S. codes is the Grade A Pasteurized Milk Ordinances published by the U.S. Department of Health and Welfare Public Health Service (1978) and recommended to states and local health agencies for legal adoption. The recommended ordinance also regulates Grade A milk and milk products in interstate commerce. Approximately 40% of the milk produced in the United States is consumed as fluid milk and creams (Table 2.1).

PLAIN MILKS

Fresh raw milk that complies with sanitary standards for consumption as fluid milk or cream is usually clarified, standardized to a certain fat test, or separated into cream and skim milk.

Whole Milk

Most fluid milk is consumed in the form of pasteurized-homogenized vitamin D-fortified whole milk. After standardization of the milkfat, which may vary from 3.0 to 3.8% (usually 3.25% in the United States), the milk is pasteurized, homogenized, packaged, and stored under refrigeration until sold. Its shelf life, as well as that of most other fluid milk products, is 10 to 14 days. Milk solids-not-fat content of 8.25% is required by most states in the U.S. as well as in most other countries.

Lowfat Milks

Per capita consumption of lowfat and skim milk has increased

Table 2.2

U. S. Federal Standards for fluid milk products (FDA. 1981A; USDA, 1981B).

	Milkfat		Solids TS		Vit A	Vit D	Stabilizer		Titratable acidity
	Min %	Max %	Min%	Max %	IU/qt	IU/qt	% Min	% Max	Min%
Whole milk	3.25		8.25		2000[2]	400[2,3]			
Lowfat milk	0.5	2.0	8.25		2000	400[2]			
Skim milk	<0.5		8.25		2000	400[2,3]			
Acidified milk[4]	3.25		8.25		2000[2]	400[2]			0.5
Cultured milk	3.25		8.25		2000[2]	400[2]			0.5
Acidified skim milk[4]	<0.5		8.25		2000[2]	400[2]			0.5
Cultured skim milk	<0.5		8.25		2000[2]	400[2]			0.5
Yogurt	3.25		8.25						0.9
Lowfat yogurt	0.5	2.0	8.25						0.9
Nonfat yogurt	0.5		8.25						0.9
Egg nog[5]	6.0		8.25						
Light cream	18.0	30.0							
Light whipping cream	30.0	36.0							
Heavy	36.0	<36.0							
Sour cream[6]	18.0						0.1	0.5	
Acidified sour cream	18 0						0.1	0.5	
Half and half	10.5	18.0							
Sour half and half	10.5	18.0							0.5
(Acidified sour half and half)	10.5	18.0							0.5

[1]Expressed as lactic.

[2]Optional, but when added, not less than quantity shown.

[3]Quantity shown is amount specified when added. Federal labeling laws must be followed.

[4]Contains one or more optional acidifying ingredients. Adipic acid, citric acid, fumaric acid, glucono-delta lactone, hydrochloric acid, lactic acid, malic acid, phosphoric acid, succinic acid, and tartaric acid.

[5]Not less than 1% egg yolk solids.

[6]If sweetener or flavoring is added, the weight of milkfat is not >18%; never <14.4% milkfat.

substantially over the past decade. In the U.S. it represented almost 30% of total fluid milk consumed in 1980. Milk with the fat content reduced below that of whole milk falls into the general classification of lowfat or skim milk. Most lowfat milks contain a designated amount of fat between 0.5 and 2.5%, frequently 1 to 2% additional milk solids, with vitamin D often added. The milk is pasteurized, homogenized, packaged, and refrigerated until sold. In the United States most states allow lowfat milks with fat contents of 0.5, 1.0, 1.5, or 2.0% but require that the percentage be shown on the label.

Skim Milk

After all or most of the milkfat is removed from whole milk by continuous centrifugal separation, the resulting skim milk is fortified with 2000 USP units of vitamin A per quart and often with additional milk solids and vitamins, then pasteurized, packaged, and refrigerated until sold. The addition of vitamin D is optional but when added must be not less than 400 USP units per quart and this must be shown on the label.

Low-sodium Milk (Hargrove and Alford. 1974).

Low-sodium milk is available in some areas as a specialty products for consumers who require low-sodium foods. It is produced by passing normal milk over an ion-exchange resin which

replaces the sodium of the milk with potassium. The normal sodium content of milk is reduced from 50 mg/100 ml to approximately 3 mg/100 ml; other components of milk remain essentially the same.

UHT Sterile Milk

Rapid increases in production and sales of sterile, fluid milk in Europe and its entry into new markets around the world merit its consideration in this chapter. Although the gross composition of UHT sterile, aseptically-packaged milk is essentially the same as its pasteurized counterpart, differences in its properties and minor constituents should be mentioned.

UHT milk differs from pasteurized milk mainly in the heat treatment employed for sterilization. Usually UHT milk is heated to 130^{o} to 150^{o}C for 2 to 8 seconds, then is aseptically packaged. In the final heating stage, steam is injected directly into the milk, or milk is infused into a steam chamber followed by a flash evaporation to remove added water (steam). An alternate procedure, the "indirect" method, involves heating the milk across a stainless steel barrier with high pressure steam as the heating media (Mehta. 1980).

Probably the most important difference between UHT and pasteurized milk is flavor, UHT milk has an intense cooked flavor immediately after processing that dissipates in about one week;

a stale flavor develops 3 to 4 weeks after the milk is processed and gets progressively worse. Not all researchers agree on the intensity and significance of the flavor of UHT (Anon. 1981C), and the many factors that influence it (Mehta 1980).

The other difference that has been observed is some alteration in minor chemical and biochemical components. Burton (1969) reported that, in general, vitamins are more stable under UHT processing than with pasteurization; however, UHT milk loses significant amounts of riboflavin and ascorbic acid during prolonged storage (Mehta 1980). Although free calcium is reduced, the availability of calcium does not change in UHT milk processed by the indirect method (Mehta 1980), according to Hansen and Melo (1977) cysteine and cystine (as cysteic acid), and methionine concentrations were reduced by about 34% by UHT processing (Aboshana and Hansen 1977). There is a decrease in the chemically available lysine is whey protein by <10% and in an insignificant difference of available lysine in casein protein by UHT processing (Douglas et al. 1981). However, a study in Holland reported that 200 children drinking UHT milk gained 7 g more per day than 200 drinking pasteurized milk. Also, the normal weight loss immediately after birth was regained sooner by the UHT-fed infants (Anon. 1979A). For additional information on chemical and biochemical changes associated with UHT sterile milk or the processing procedures, the reviews by Burton (1969, 1977) and Mehta (1980) are recommended.

A ruling by the U.S. Food and Drug Administration to approve the use of hydrogen peroxide and heat as sterilizing agents for aseptic packaging has encouraged some U.S. dairy companies to enter the UHT market (Anon. 1981B). Resistance among other dairy industry leaders to make this investment stems from a concern with regard to flavor stability, economics, and package size (liter size containers) of UHT milk.

FLAVORED FLUID MILK PRODUCTS

Fluid milk and fluid milk products may be flavored with such ingredients as chocolate, vanilla, eggnog, and fruit juices. In the United States all of the previously described fluid milk products (milk, lowfat milk, and skim milk) may be flavored. Characteristic flavoring ingredients such as fruit and fruit juices, natural and artificial food flavorings with or without coloring, nutritive sweetners, emulsifiers, and stabilizers may be added as optional ingredients (FDA. 1981A).

The most popular flavored milk or milk drink in the United States is chocolate milk or chocolate lowfat milk. Typically, chocolate milk contains about 1% cocoa, 6% sucrose, 0.2% stabilizer such as a vegetable gum, vanilla, and salt, all added to whole milk. Particular attention must be given to stabilizing the chocolate flavoring ingredients against sedimentation.

Eggnog is a flavored dairy drink with seasonally maximum sales in November to December in the U.S. It must contain 6% milk fat and 1% egg yolk, with up to 0.5% stabilizer, and about 7% sugar. Flavorings include nutmeg, cinnamon, vanilla, and rum concentrate.

FERMENTED AND ACIDIFIED MILKS

Fermented milks are cultured dairy products manufactured from whole, partly skimmed, skim, or slightly concentrated milk. Specific lactic acid bacteria or food grade acids are required to develop characteristic flavor and texture of these beverages. Fermented milks are either fluid or semi-fluid in consistency with various proportions of lactic acid. Fermented products are regulated by federal standards in the United States as given in Table 2.2. While other fermented milks without federal standards established are regulated by state standards. Compositional standards for fermented milk have been proposed by the International Dairy Federation (Hargrove and Alford 1974). Typical analyses of various fermented milks as well as their condensed and dried counterparts are given in Table 2.4.

U.S. federal standards have recently been established for several acidified fluid milk products that simulate such cultured products as acidified milk, acidified lowfat milk, and acidified

skim milk (FDA. 1981A).

Acidified milks are made by souring the product, used alone or in combination with one or more acidifying ingredients, with or without characterizing microbial organisms added. Specified acidulants are citric acid, fumaric acid, glucono-delta lactone, hydrochloric acid, lactic acid, malic acid, phosphoric acid, succinic acid, and tartaric acid.

Buttermilk

Cultured buttermilk is manufactured by fermenting whole milk, reconstituted nonfat dry milk, partly skimmed milk or skim milk with lactic acid bacteria. Most commercial, cultured buttermilk is made from skim milk. Mixed strains of lactic streptococci are used to produce lactic acid and leuconostocs for characteristic diacetyl flavor and aroma. Buttermilk is similar to skim milk in composition, except it contains about 0.9% total acid expressed as lactic acid. The percentage of lactose normally in skim milk is reduced in proportion to the percentage of lactic acid in the buttermilk. According to White (1978), fat contents usually vary from 1 to 1.8% and are sometimes in the form of small flakes or granules, to simulate churned buttermilk, the by-product of butter churning. Usually 0.1% salt is added.

A few U.S. states require buttermilk to be labelled as cultured whole-milk buttermilk with a minimum of 3.5% milkfat or

cultured lowfat milk with a minimum of 0.5% and maximum of 2.0% milkfat or cultured skim milk with a maximum of 0.5% milkfat. When buttermilk is made with low-heat powder, higher solids (10%) usually are used to give a firmer body with less shrinkage and less whey separation during storage (White 1978).

A product similar to cultured buttermilk may be prepared by direct acidification. Food grade acids and acid anydrides are added to unfermented milk to obtain a product with uniform acidity and smooth body characteristic. Flavoring materials are used to improve the flavor and aroma.

Bulgarian buttermilk is similar to cultured buttermilk except the whole or partly skimmed milk is fermented by Lactobacillus bulgarius. With a titratable acidity of 1.2 to 1.5% expressed as lactic acid, it is more acidic than cultured buttermilk.

Sour Cream

Sour cream is fermented cream that has been soured by lactic acid bacteria or by adding food grade acids directly. According to United States federal standards both sour cream and acidified sour cream must contain not less than 18% milkfat with a titratable acidity of not less than 0.5% expressed as lactic acid (FDA. 1981A). Optional ingredients are used to improve texture, prevent syneresis, and extend shelf life. Sour cream may contain not more than 0.1%

sodium citrate, salt, rennet, nutritive sweeteners, flavoring, or coloring.

It is prepared by mixing milkfat and skim milk, nonfat solids, and other ingredients. The mix then is pasteurized, homogenized, cooled to setting temperature, then starter and enzymes are added and the cream is allowed to ripen. After ripening, it is cooled for 24 hours before packaging.

In direct acidification, the cream is pasteurized, homogenized, cooled to setting temperature and the food grade acid is added. Then cream is packaged and the characteristic body is formed as the product cools in the container (Schanback 1977).

Acidophilus Milk

Acidophilus milk is a sharp, harsh, acidic cultured milk produced by fermenting whole or skim milk with active cultures of Lactobacillus acidophilus. Honey, glucose, and tomato juice may be added as nutrients to stimulate bacterial growth and contribute flavor. Plain acidophilus milk has the same composition as whole milk or skim milk except that part of its lactose is converted from 0.6% to 1% lactic acid by the culture organisms. Speck (1976), who proposed addition of Lactobacillus acidophilus organism to pasteurized milk (Sweet Acidophilus Milk), describes the beneficial effects of implanting the organisms in the human intestines.

Sweet acidophilus milk differs from the above in that a high concentration of viable L. acidophilus organisms is added to cold pasteurized milk and kept cold. At low storage temperature (4.4°C), these organisms do not multiply, so the flavor and other properties of "Sweet Acidophilus" are identical to fresh fluid milk. The inoculated milk is promoted largely for containing several million viable L. acidophilus per ml.

One of the acidophilus products called "Di-gest" is a pasteurized, homogenized lowfat milk with added L. acidophilus fortified with vitamins A and D. In the United States an "Acidophilus Yogurt" flavored in the conventional manner also is manufactured. Denmark markets a culture product consisting of 90% normal yogurt and 10% acidophilus, and the Soviet Union produces "Biolact," a product particularly for children. According to Lang and Lang (1978), it is made with selected cultures of L. acidophilus organisms with high proteolytic activity and "antibiotic properties."

A thick milky white-to-creamy coagulum with a pleasant lactic odor and refreshing clean aromatic taste is produced in Northern Bohemia. This product after ripening has organoleptic qualities similar to kefir. It is produced from two different cultures and incubation temperatures with these coagula subsequently blended; one culture of L. acidophilus fermenting milk to produce a thick, typically sharp, acid-tasting coagulum with an acidity of 1.9 to 2.3% lactic acid; the other culture identified as "strains of

cream cultures" yields a thick, aromatic coagulum with a lactic-acid flavor and acidity of 0.8 to 0.9% lactic acid from a culture cream. The two coagulated products are mixed one part of the thick cream culture to nine parts of the acidic L. acidophilus culture. The similarity of kefir probably occurs because the ratio of Streptococci to Lactobacilli is similar to that of kefir; however, the ripening process is simpler (Lang and Lang 1978).

Yoghurt

Yoghurt is a fermented milk product made by culturing whole or partly defatted milk to which either nonfat dry milk solids or skim milk concentrates have been added. Its texture may vary from a rennet-like custard to a creamy, highly viscous liquid, depending on the milk solids and fat content. A mixed culture of Streptococcus thermophilus and Lactobacillus bulgaricus growing together symbiotically produces its approximately 0.9% lactic acid and the characteristic yogurt flavor.

Keogh (1970) reported that yogurt-type products (yaaurt, jugurt, yeart, yaoert, yogurt, yahourt, and yourt) have seen made for centuries, originating in countries on the eastern Mediterranean. Similar products, such as leben of Egypt, Madzoon of Armenia, and dahi of India, all are fermented by L. bulgaricus and S. thermophilus. Turkish yoghurt differs only in that a lactose-fermenting yeast is included in the culture. Interest in yoghurt

in the United States has been recent. According to Milk Industry Foundation, Milk Facts (1981), from 1969 to 1979 per capita sales of yoghurt in the U.S. increased by 211%, and yoghurt now represents about 1% of fluid milk sales.

Yoghurt-type products in wide variety have found their way to supermarket shelves. In addition to plain or natural yoghurt, the following products are marketed in the United States (Tamine and Deeth 1980):

Fruit yoghurts - both Swiss-style, with fruit, flavoring, and color uniformly distributed and Sundae-style, with fruit in the bottom of the cup and yoghurt on the top.

Pasteurized/UHT yoghurt - heat treated after incubation for longer shelf life.

Concentrated yoghurt (frozen yoghurt) - resembles either soft or hard ice cream.

Dried yoghurt - produced by sun, spray, or freeze drying yoghurt.

Low-calorie yoghurt - contains 9% solids-not-fat, 0.1% fat, and 0.5 - 1% stabilizer.

Low-lactose yoghurt - made with α-D-galactosidase with lactose hydrolyzed for a sweeter product with no added sugar.

Kefir Cultured Milk

Kefir is a self-carbonated beverage popular in the Soviet

Union, Poland, Germany, and other European countries in plain and flavored forms (Kosikowski. 1978B). Made with whole, part skim, or skim milk, it contains about 1% lactic acid and 1% alcohol. Kefir exists in various forms: whole-, milk-, cream-, skim milk-, whey-, acidophilus-, pepsin-, grape-sugar-, and fruit-flavored kefir. Kefir buttermilk is a kefir-like product that contains less CO_2 and alcohol than normal kefir.

Basically, kefir is made with the fermenting agent called "Kefir Grains" that consists of casein and gelatinous colonies of micro-organisms growing together symbiotically. The dominant microflora of kefir consist of Saccharomyces kefir, Torula kefir, Lactobacillus caucasicus, Leuconostoc spp. and lactic acid streptococci. The microbial population is 5 to 10% yeast. Often, the "Kefir Grains" surface is covered with white milk, Geotrichum candidum, which apparently does not detract much from quality (Kosikowski. 1978A). Kefir milk differs in composition from the original milk as some of the lactose is converted to lactic acid, alcohol, and carbon dioxide. It has a definite yeasty aroma with limited proteolysis in the milk. The taste of kefir differs markedly from that of yoghurt (Kosikowski. 1978B). Production of lactic acid, which in turn is converted to alcohol and CO_2, may be regulated by the incubation temperature.

Kumiss

Kumiss (Koumiss, Kymys) is an effervescent, lactic acid-alcoholic fermented milk, similar to kefir. It originated in the Asiatic Steppes and is traditionally made from mare's milk. Due to a shortage of mare's milk, the Soviet Union manufactures large quantities of Kumiss from cow's milk, so it differs somewhat from kefir. According to Keogh (1970) it is enjoying a reputation comparable to that of yoghurt at the time of Metchinoff. Starter organisms used for its manufacture are Lactobacillus bulgaricus, Lactobacillus acidophilus, and Saccharomyces lactis, a lactose-fermenting yeast. Puhan and Gallman (1980) reported that a modified Kumys can be made with cow's milk diluted 20 to 25% with whey or water to adjust the protein concentration to approximately that of mare's milk; 2 to 3% glucose or sucrose is added and this is pasteurized at 90 - 96°C, and cooled to 45°C. This modified milk is fermented at 37°C with 3 to 5% added culture. Four to eight hours after 0.5% acid is developed, the milk is cooled, then stirred at 30°C while 2.5 g of yeast per liter is added. The product is incubated 4 to 16 hours according to the alcohol concentration desired. Traditional Kumiss from mare's milk contains about 2.5% alcohol and approximately 1% lactic acid. Any movement of the protein particles in milk produces an unstable product because CO_2 escapes during lactic acid fermentation. Unsatisfactory

fermentation can be improved by hydrolyzing lactose with a β-galactosidase.

CONCENTRATED FERMENTED MILKS

Danish Ymer and Swedish Lactofil are very soft, white, fermented milk-products, smooth and light with a milk aromatic and acidic flavor. They are made from whole or skim milk and are used for desserts topped with fruits and in salads and dips. Ymer and Lactofil are made by fermenting the milk with lactic acid cultures, including Streptococcos diacetilactis and Leuconostoc sp., to form a curd. After coagulating, the curd is cooked moderately until 55% of the whey is removed. Then cream is added and the mass is homogenized to a smooth, creamy consistency before cooling. The products contain 3% fat, 7% protein, and 12% SNF (Lang and Lang 1970).

FLUID CREAM

Several types of fluid creams are manufactured and sold directly to consumers. The most significant difference in the creams is the level of milk fat they contain: from as little as 10% in half and half to 40% for whipping creams. All commercial creams are derived from centrifugally separating of the less-dense, higher-fat products from residual skim milk. Most often cream with

40% fat is separated and standardized with skim milk to give creams with desired fat contents. In some instances, creams of desired fat contents are collected directly from the separator; in other cases, as in "Plastic Cream" (made for manufacturing purposes), a 40% cream is pasteurized and reseparated while hot to yield a product with 80% fat.

Fluid creams for consumer markets throughout the world fall into certain classes, depending upon fat content: 10 to 12%, 18 to 10%, 25 to 30%, 34 to 36%, and 48%, although not all countries market all types. Their names are not always the same; for example, a product with 20 to 30% fat is designated "Medium Cream" in the United States but "Reduced Cream" in Australia. The term "cream" officially varies from 18% (Food and Agricultural Organization) to 40% (New Zealand).

Half and Half

The composition and properties of particular types of creams depend upon their intended use. Half and half with 10 to 12% fat is used as a coffee whitener and cereal cream. It may have additional milk solids and a stabilizer added. Usually half and half is homogenized and either pasteurized or ultrapasteurized for longer shelf life. In some countries it is sterilized. Most states in the United States require a minimum of 10.5% and a maximum of 18% milkfat.

Table Creams

Table or coffee creams are those of intermediate fat content. In the United States they are classified as "Light" (18% fat) and "Medium" (30% fat), whereas in the United Kingdom they are designated "Cream" (20% fat) and "Sterilized Cream" (23% fat). Other than sterilized creams, the table creams are standardized to the desired fat test, pasteurized, and packaged. To extend shelf life, sterilized creams, as well as some table creams that are ultrapasteurized, are aseptically packaged.

Whipping Cream

Whipping cream varies in fat content from 30% fat for light whipping cream to 36% fat for heavy whipping cream. It is usually processed in a manner to increase its viscosity and thickness and to enhance its whipping ability. Increasing the fat content, aging the cream, and adding nonfat dry milk solids will improve whipping ability.

Standards for creams in the United States are presented in Table 2.2 and typical compositions of these products in Table 2.3.

CONCENTRATED MILK PRODUCTS

Whole milk, skim milk and buttermilk are concentrated by removal of water and may be preserved by heat, addition of sugar,

Table 2.3

Typical composition of market creams, butter, and frozen desserts (USDA. 1981C; Hargrove and Alford 1974).

	Market Creams:	Moisture %	Protein %	Total fat %	Total carbo-drate %	Ash %	Calci-um %	Phos-phorus %	Sodium %
Fluids:	Half and Half (milk & cream)	80.6	3.0	11.5	4.3	0.7	0.10	0.09	0.04
	Light, coffee or table	73.7	2.7	19.3	3.7	0.6	0.10	0.08	0.04
	Medium, 25% fat	68.5	2.5	25.0	3.5	0.5	0.1	0.07	0.04
	Light whipping	63.5	2.2	30.9	3.0	0.5	0.07	0.06	0.03
	Heavy whipping	57.7	2.0	37.0	2.8	0.4	0.06	0.06	0.04
Whipped:	Cream topping, pasteurized	61.3	3.2	22.2	12.5	0.8	0.10	0.09	0.13
	Sour half and half (cultured)	80.1	2.9	12.0	4.3	0.7	0.10	0.09	0.04
	Butter and butter oil:								
	Regular or whipped	15.9	0.85	81.1	0.06	2.1	0.02	0.02	0.83
	Butter oil, anydrous	0.2	0.3	99.5	0.0	0.0			
	Ghee	0.1	0.1	99.8	0.0	0.0			
	Frozen desserts:								
Ice cream, vanilla hardened									
	Regular (10% fat)	60.8	3.6	10.8	23.8	1.0	0.13	0.10	0.09
	Rich (16% fat)	58.9	2.8	16.0	21.6	0.7	0.10	0.08	0.07
Ice cream, French Vanilla, soft served		59.8	4.0	13.0	22.1	1.0	0.14	0.11	0.09
Ice milk, Vanilla									
	Hardened	68.6	3.9	4.3	22.1	1.0	0.13	0.10	0.08
	Soft served	69.6	4.6	2.6	21.9	1.2	0.16	0.11	0.09
Sherbet, orange		66.1	1.1	2.0	30.4	0.4	0.05	0.04	0.05

or refrigeration. Typical analyses of these products are given in Table 2.4

Evaporated Milk

This product is made by the evaporation of water from whole milk under vacuum. Low percentages of sodium phosphate, sodium citrate, calcium chloride, and/or carageenan may be added to improve stability. The concentrate is homogenized, canned, then sterilized under pressure at 117°C for 15 minutes or 126°C for 2 minutes. Ultra-high temperatures (130 to 150°C for a few seconds), followed by aseptic packaging have been applied with some success but have found limited commercial application.

U.S. Standards of Identity require that evaporated milk contain not less than 7.5% milkfat and 25% total milk solids. In addition it must contain 25 USP units of vitamin D per fluid ounce. Addition of vitamin A is optional; if added, it must be present at concentrations of 125 USP units per fluid ounce (FDA. 1981A). U. S. Standards for evaporated and condensed milks are essentially the same as those published by FAO/WHO. Codex Alimentarius (Food and Agricultural Organization 1973) and similar througout the world.

Plain Condesned Milk

Plain condensed milk or concentrated milk has the same

standard of identity in the United States as evaporated milk, except that it is not given additional heat processing after concentration. This product is shipped in bulk contianers and is perishable. Technology is available to produce it in a sterile or almost sterile manner, and its extended shelf life gives it a potential, but as yet undeveloped, market as a source of beverage milk. Whole milk can be successfully concentrated up to 45% total solids, and these higher concentrations have found some use in the bulk product market.

Sweetened Condensed Milk

Sweetened condensed milk is made by the addition of approximately 18% sugar to whole milk, followed by concentration under vacuum to approximately one-half the volume. The product is canned without sterilizing, for the sugar acts as a preservative.

Federal standards of identity require 8.5% fat, 28.0% total milk solids and sufficient sugar to prevent spoilage. State standards range from 7.5 to 8.5% fat and 25.0 to 28% total milk solids (USDA. 1981B).

Condensed Skim Milk

Plain condensed skim milk - is usually sold in bulk in the United States for increasing milk solids in ice cream, bakery goods, and many other foods. It is usually less expensive, though

more perishable, than nonfat dry milk. There are no federal standards but states require 18 to 20% total solids-not-fat.

Sweetened condensed skim milk - This product is prepared from skim milk in a process similar to that used for whole milk. The final product contains at least 60% sugar and 72 to 74% solids. U.S federal standards require not less than 0.5% milk fat and 24% total milk solids. It must have sufficient sweetener to prevent spoilage (USDA. 1981B).

Condensed skim milk, acid - This is a product manufactured primarily for animal feed. It is made from skim milk by developing about 2% acidity from a lactobacillus culture and a mycoderm, thus concentrating the milk to about 1/3 its weight.

Condensed Buttermilk (Hargrove and Alford 1974)

Condensed on semi-solid buttermilk is a creamery buttermilk (usually from sweet cream) which is allowed to ripen to an acidity of 1.6% or more, then condensed. It has found limited use in the baking industry. There are no federal standards, but a typical product contains about 28% total solids.

DRIED MILK PRODUCTS

Typical analyses of dried milk products are given in Table 2.4.

Nonfat Dry Milk

Nonfat dry milk (NDM) is an important commodity of the diary industry. According to the American Dry Milk Institute (1982) the 1.2 billion pounds manufactured in the U.S. in 1980 accounts for nearly 10% of the total milk supply. In several other leading milk producing countries 20% or more of the milk supply goes to produce NDM (see Table 2.1). It provides a convenient way for countries with fluid milk surpluses to market their milk.

Nonfat dry milk is produced from skim milk by condensing with conventional equipment followed by spray or drum drying. The drum dried product is relatively insoluble and is used principally for animal feeds. Over 95% of NDM in the United States is used for human foods (American Dry Milk Institute 1982) and is produced by spray drying. Most instant NDM is made by rewetting the conventionally spray dried product, allowing the particles to agglomerate, then reducing the moisture content with added heat. Foam spray drying by spray drying a pressurized concentrated milk also gives a very acceptable product.

NDM has only fat and water removed. Federal Standards of Identity in the United States and FAO/WHO require a maximum of 5% moisture and not more than 1.5% milkfat (FDA. 1981A; Food and Agricultural Organization 1973).

Percent composition of concentrated milk and dried products (Posati and Orr 1976; Hargrove and Alford 1974)

Milk products:	Moisture	Protein	Total Fat	Total carbo-hydrate	Ash	Calcium	Phos-phorus	Sodium	Potas-sium	Lactic acid
	%	%	%	%	%	%	%	%	%	%
Concentrated										
Evaporated milk										
Whole	74.0	6.8	7.6	10.0	1.5	0.26	0.20	0.10	0.30	0
Skim	79.4	7.5	0.2	11.3	1.5	0.29	0.19	0.11	0.33	0
Sweetened condensed										
Whole	27.1	7.9	8.7	54.4	1.8	0.30	0.25	0.13	0.37	0
Plain condensed skim	73.0	10.0	0.3	14.7	2.3	0.25	0.20			0
Sweetened condensed skim	28.4	10.0	0.3	58.3	2.3	0.30	0.23			0
Condensed buttermilk (acid)	72.0	9.9	1.5	12.0	2.2					5.7
Condensed skim (acid)	72.0	10.2	0.2	9.4	2.1					6.08
Condensed whey	48.1	7.0	2.4	38.5	4.0					2.4
Sweetened condensed whey	24.0	5.0	1.7	66.5	2.8					0
Dried										
Whole	2.5	26.3	26.7	38.4	6.1	0.91	0.80	0.40	1.33	0
Nonfat										
Regular	3.2	36.2	0.8	52.0	7.9	1.26	0.97	0.53	1.79	0
Instantized	4.0	35.1	0.7	52.2	8.0	1.23	0.99	0.55	1.70	0
Buttermilk (sweet cream)	3.0	34.3	5.8	49.0	7.9	1.18	0.93	0.52	1.59	0
Buttermilk (acid)	4.8	37.6	5.7	38.8	7.4					5.7
Malted Milk										
Natural flavor (powder)	2.6	13.1	8.5	72.5	3.4	0.27	0.37	0.46	0.76	0
Chocolate flavor (powder)	2.0	6.5	4.5	84.9	2.1	0.06	0.18	0.23	0.62	0
Cream	0.8	65.0	13.4	18.0	2.9					0
Whey (acid) cottage	3.5	11.7	0.5	73.4	10.8	2.05	1.35	0.97	2.29	8.6
Whey (sweet) cheddar	3.2	12.9	1.1	74.5	8.3	0.80	0.93	1.08	2.08	2.3
Casein (commercial)	7.0	88.5	0.2	0	3.8					
Casein (co-precipitate)	4.0	83.0	1.5	1.0	10.5	2.5				

Dried Whole Milk

Dried whole milk is prepared by conventional spray or roller drying with some modifications of the preheat treatment of the milk. The product is usually stored under nitrogen to delay lipid oxidation and off-flavor development. In spite of the processing changes, flavor defects and short storage life have limited the markets for dried whole milk; most of that produced is utilized in the confectionery and baking industries. Federal and FAO standards require a *minimum* of 20% but less than 40% milkfat and a maximum of 5% moisture.

Dry Buttermilk

Most dry buttermilk is prepared from sweet cream buttermilk, which is produced in a manner similar to that of nonfat dry milk. Dry buttermilk has a higher phospholipid content than other dry milk products and therefore is a natural emulsifier for use in the dairy and baking industries and for dry mixes and other foods. A dry, high acid buttermilk can be produced from milk fermented by Lactobacillus bulgaricus. It is difficult to dry, however, and has found only a limited use in the baking industry. There are no United States and FAO standards for this product, although typically the moisture content is less than 5%.

Dry Cream

Dry cream may be produced by spray drying or foam drying a good quality standardized cream. Higher heat treatments and gas packaging to reduce oxygen headspace to 0.75% or less make the product more resistant to oxidation. United States standards require a minimum of 40% but less than 75% milkfat and a maximum of 5% moisture (FDA. 1981A). FAO standards require a minimum of 65% milkfat (Food and Agricultural Organization 1973). The solids-not-fat content is usually higher than in normal market creams. A foam spray-dried sour cream also has been manufactured. A cream tablet has been produced containing added lactose to aid tableting, but the commercial acceptance of this product is negligible.

Malted Milk Powder (Hargove and Alford 1974)

Malted milk powder is made by concentrating a mixture of milk and an extract from a mash of ground barley malt and wheat flour, to obtain a solid which is ground to powder. It usually contains less than 7.5% milkfat and not more than 3.5% moisture. One pound is considered equivalent to 2.65 pounds of fluid milk on the basis of fat content. This difference in equivalents results from using milk containing approximately 2.0% fat in making malted milk.

BUTTER, BUTTER OIL, SPREADS

Butter

Most creamery butter is produced by churning sweet cream so that the fat globules coalesce into a soft mass. The federal standard for butter (USDA. 1981B) requires not less than 80% milkfat. FAO/WHO standards specify 80% milkfat and also not more than 16% water and a maximum of 2.0% nonfat milk solids (Food and Agricultural Organization 1973). The required fat level is universal. A typical analysis of butter is given in Table 2.3. Whey butter has a similar composition, but is derived from the milkfat recovered from cheese whey.

Butter Oil

Butter oil or anhydrous milkfat is a refined product prepared by centrifuging melted butter or by separating the milkfat from high-fat cream. There are no federal standards in the United States, but FAO has published standards of 99.3% fat and 0.5% moisture for butter oil, and 99.8% fat and 0.1% moisture for anhydrous butter oil in Codex Alimentarius (Food and Agricultural Organization 1973).

Ghee (Hargrove and Alford 1974)

Ghee is a nearly anhydrous butterfat used in many parts of

India and Egypt. It is usually made from buffalo milk and much of the typical flavor comes from the burned nonfat solids remaining in the product. Ghee is made in the United States from butter, and recently a procedure has been developed for its production from cheese.

Miscellaneous Spreads

Several dairy spreads and products simulating butter have emerged in the past decade. Butterine developed in Wisconsin in 1967 is composed of at least 40% milk fat, 38 to 40% margarine, 1% milk solids, salt and added vitamins A and D. The spreadability of this product is improved over that of butter and its flavor improved over that of margarine. It is legal only in Wisconsin where state standards require that it contains a minimum of 40% butterfat. South Dakota has standards for "Dairy Spread" or "Dari Spread" that must contain not less than 38% nor more than 44% milkfat and not less than 30% milk solids-not-fat with optional ingredients of salt, artificial flavoring, coloring and thickening agents (USDA. 1981B). A lowfat spread, that is allowed under Ohio state standards, is required to contain at least 30% milkfat, but the word "butter" must not be used on the label.

Other low-calorie spreads containing about 50% moisture and 40% milkfat have been developed in the United States, Canada,

Ireland and Sweden.

A product was developed at the University of South Dakota that contains 44% moisture, 40% milk fat and, 14 to 16% nonfat dry milk, synthetic butter flavor, high-acid starter distillate, salt, butter coloring, and a combination of gelatin and sodium carboxymethylcellulose as a stabilizer.

A spread-type product, "Bregott," in which 15% of the total fat is soybean oil, is marketed in Sweden. The oil is added to cream and then churned with minor adjustments in temperature and time. Although it is not competitive with the best margarines in price, it is a well accepted spread (Hargrove and Alford 1974).

CHEESE

Cheese is a concentrated dairy food produced from milk curds that are separated from whey. The curds may be partially degraded by natural milk or microbial enzymes during ripening, as in cured cheeses, or they may be consumed fresh, as in uncured cheeses like cottage cheese. Most commonly, a bacterial culture with the aid of a coagulating enzyme like rennin is responsible for producing the initial curd. The starter culture also provides important proteolytic and lipolytic enzymes to produce the characteristic texture and flavor during ripening.

Although cow's milk (whole, lowfat, skim, whey, cream, nonfat

dry milk, or buttermilk) generally is used for manufacturing cheese in the United States, a small quantity of ewe's and goat's milk also is used (USDA. 1978). Certain other countries even use milk from camels, asses, mares, buffaloes, and reindeer milk, in addition to ewe's and goat's, to make cheese.

Casein, the major protein in milk and in cheese, is coagulated by acid that is produced by selected microorganisms and/or by coagulating enzymes to form curds. Acidification by food grade acidulants also is used for the manufacture of some types of cheese like cottage cheese. Lactalbumin and lactoglobulin are water-soluble protein comprising 1/5 of the total protein in milk. These two proteins do not coagulate with the acidity and temperatures used in manufacture of most cheese. The amount of whey retained in the cheese curd will determine the amount of residual water-soluble nutrients such as water soluble protein and lactose in the cheese.

Minerals found in milk which are insoluble remain in water in the curd and are more concentrated in the cheese than in milk. About 2/3 of calcium and 1/2 phosphorus of milk remains in cheese. A major portion of the milk calcium is retained in the curd of cheese made with coagulating enzymes. Acid coagulation alone results in the loss of portions of both calcium and phosphorus salts in the acid whey since these minerals are more soluble in the

acidic media. Most milk fat and fat-soluble vitamins are retained in the curd but a considerable amount of water soluble vitamins is lost during cheese manufacture. Retention of part of some B-complex vitamins in curd is due to their extended association with casein in the original milk.

A cheddar-type cheese retains 48% of total solids of milk, 96% casein, 4% soluble proteins, 94% fat, 6% lactose, 6% H_2O, 62% calcium, 94% vitamin A, 15% thiamin, 26% riboflavin, and 6% vitamin C (National Dairy Council 1979). Lactose content varies in freshly prepared cheeses and decreases rapidly during ripening, completely disappearing in four to six weeks. The enzymes and ripening agents responsible for the rate and extent of fat and protein decomposition are fully discussed in Chapter 12, and vitamin variation in relation to fat, solid, and moisture contents is discussed in Chapter 11.

Classification

More than 400 cheeses are known throughout the world. They are usually named after the town or community of manufacture. Successful classification is difficult, if not impossible. There are probably 18 types or kinds of natural cheeses that differ distinctively in process of manufacture from setting of milk, cutting, stirring, heating, draining, and pressing which may be varied to produce peculiar qualities of each cheese. Examples are Brick,

Camembert, Cheddar, Cottage, Cream, Edam, Gouda, Hard, Limburger, Neufchatel, Parmesan, Provolone, Romano, Roquefort, Sapsago, Swiss, Trappist, and Whey cheeses (Mysost and Ricotta) (USDA. 1978).

The classification presented here is based upon consistency brought about by differences in moisture content (soft, semi-soft, hard, very hard), manner of ripening (bacteria, mold, yeast, surface or interior micro-organisms, combinations or unripened), method by which curd is produced (acid/or coagulating enzymes or by acid and high heat or combinations) and type of milk employed (National Dairy Council 1979).

The most significant and distinguishing characteristic is used for the classification. Typical analyses of two or three representative cheeses that are classified on the basis of moisture content and manner of ripening are presented in Table 2.5. Federal Standards of Identity are given in Table 2.6 for some selected cheeses. For an in depth study of cheeses, the author recommends Kosikowski's (1978A), 2nd ed. of Cheese and Fermented Milk Foods.

Cottage Cheese

Cottage cheese is a soft, unripened acid cheese made with the coagulated curd from various combinations of skim milk, partially condensed skim milk, and/or reconstituted low-heat, nonfat dry

Table 2.5

TYPICAL ANALYSES OF CHEESES(Posati and Orr 1976; Hargrove and Alford 1974).

Type	Cheese	Moisture %	Protein %	Total fat %	Total Carbohydrate %	Fat in dry matter %	Ash %	Calcium %	Phosphorus %	Sodium %	Potassium %
Soft-unripened Low-fat	Cottage (dry curd)	79.8	17.3	0.42	1.8	2.1	0.7	.03	0.10	0.01	0.03
	Creamed cottage	79.0	12.5	4.5	2.7	21.4	1.4	.06	0.13	0.40	0.08
	Quarg	72.0	18.0	0.0	3.0	28.5		0.30	0.35		
	Quarg (high fat)	59.0	19.0	18.0	3.0			0.30	0.35		
Soft-unripened High-fat	Cream	53.7	7.5	34.9	2.7	75.4	1.2	.08	0.10	0.29	0.11
	Neufchatel	62.2	10.0	23.4	2.9	62.0	1.5	.07	0.13	0.39	0.11
Soft-ripened by surface bacteria	Limberger	48.4	20.0	27.2	0.49	52.8	3.8	0.49	0.39	0.80	0.13
	Liederkranz	52.0	16.5	28.0	0	58.3	3.5	0.30	0.25		
Soft-ripened by external molds	Camembert	51.8	19.8	24.3	0.5	50.3	3.7	0.39	0.35	0.84	0.19
	Brie	48.4	20.7	27.7	0.4	53.7	2.7	0.18	0.19	0.63	0.15
Soft-ripened by bacteria, preserved by salt	Feta	55.2	14.2	21.3	4.1	47.5	5.2	0.49	0.34	1.12	0.06
	Domiati	55.0	20.5	25.0		55.5					
Semi-soft, ripened by bacteria with surface growth	Brick	41.1	23.3	29.7	2.8	50.4	3.2	0.67	0.45	0.56	0.14
	Muenster	41.8	23.4	30.0	1.1	51.6	3.7	0.72	0.47	0.63	0.13
Semi-soft, ripened by internal molds	Blue	42.4	21.4	28.7	2.3	49.9	5.1	0.53	0.39	1.39	0.26
	Roquefort	39.4	21.5	30.6	2.0	50.5	6.4	0.66	0.39	1.81	0.09
	Gorganzola	36.0	26.0	32.0		50.0	5.0				

Hard, ripened by bacteria	Cheddar	36.7	24.9	33.1	1.3	52.4	3.9	0.72	0.51	0.62	0.09
	Colby	38.2	23.8	32.1	2.6	52.0	3.4	0.68	0.46	0.60	0.13
Hard, ripened by eye-forming bacteria	Swiss	37.2	28.4	27.4	3.4	43.7	3.5	0.96	0.60	0.26	0.11
	Edam	41.4	25.0	27.8	1.4	47.6	4.2	0.73	0.54	0.96	0.19
	Gouda	41.5	25.0	27.4	2.2	46.9	3.9	0.70	0.55	0.82	0.12
Very hard, ripened by bacteria	Parmesan (hard)	29.2	35.7	25.8	3.2	36.5	6.0	1.18	0.69	1.60	0.09
	Romano	30.9	31.8	26.9	3.6	39.0	6.7	1.06	0.76	1.20	
Pasta filata (stretch cheese)	Provolone	40.9	25.6	26.6	2.1	45.1	4.7	0.76	0.50	0.88	0.14
	Mozzarella	54.1	19.4	21.6	2.2	47.1	2.6	0.52	0.37	0.37	0.067
Low-fat or skim milk cheese (ripened)	Euda	56.5	30.0	6.5	1.0						
	Sapsago	37.0	41.0	7.4							
Whey cheese	Ricotta	71.7	11.3	13.0	3.0	45.9	1.0	0.21	0.16	0.08	0.10
	Primost	13.8	10.9	30.2	36.6	35.0					
Process cheese	American Pasteurized Process Cheese	39.2	22.1	31.2	1.6	51.4	5.8	0.62	0.74	1.43	0.16
	American cheese food, cold pack	43.1	19.7	24.5	8.3	43.0	4.4	0.50	0.40	0.97	0.36
	American Pasteurized Process Cheese Spread	47.6	16.4	21.2	8.7	40.5	6.0	0.56	0.71	1.34	0.24
	Pimento Pasteurized Process Cheese	39.1	22.1	31.2	1.7	51.2	5.8	0.61	0.74	1.42	0.16
	Swiss Pasteurized Process Cheese	42.3	24.7	25.0	2.1	43.3	5.8	0.77	0.76	1.37	0.22
	Swiss Pasteurized process cheese food	43.7	21.9	24.1	4.5	42.8	5.8	0.72	0.53	1.55	0.28

Table 2.6

Federal standards of identify for cheese (FDA. 1981A).

Cheese type	Moisture (maximum)	Milk fat[1] (minimum in solids)	Milk fat[2] (minimum in cheese)
	%	%	%
Cottage curd	80	--	<.5
Lowfat cottage	82.5	--	.5-2
Creamed cottage	80	--(20)	4
Cream	55	--(73.3)	33
Limburger	50	50	--(25)
Camembert	--	50[3]	--
Feta	--	50[3]	--
Brick	44	50	--(28)
Blue	46	50	--(27)
Cheddar	39	50	--(30.5)
Swiss	41	43	--(25.4)
Parmesan	32	32	--(21.8)
Provalone	45	45	--(24.8)
Ricotta	80	11	11
Pasteurized			
Process Cheddar	40	50	--(30.5)
Process Swiss	42	43	--(25.4)
Process Cheese Food	44	--(42.6)	23
Process Cheese Spread	60(44 minimum)	--(50)	20

[1]Federal Standards set on milk fat in solids. Figures in parenthesis calculated from standard of minimum milk fat in cheese.

[2]Federal Standards set on milk fat in finished cheese. Figures in parenthesis calculated from standard of minimum in solids.

[3]Federal Standards for cheese class only.

milk made primarily in the United States, Canada, and England. In some countries like Japan, cottage cheese is made principally from reconstituted nonfat dry milk. The curd is formed by the action on milk of either a combination of lactic acid from lactic acid-producing bacteria and an enzyme coagulator like rennin or by adding edible-food grade acids and a coagulator. Finished cottage cheese consists of approximately two parts of dry curd and one part of creamy dressing. The dressing usually contains salt, flavoring, and stabilizers in addition to the cream. Commercial cottage cheese is either small or large curd depending upon the size of curd particles cut before cooking.

A relatively new procedure for making cottage cheese, the direct-acid-set method, currently accounts for about one-fifth of all cottage cheese made in the United States. Using food grade acids to effect coagulation eliminates problems associated with bacterial cultures and reduces manufacturing time. Sharma et al. (1980) reported a 5% increase in yield with the direct acidification method.

United States federal standard requires that cottage cheese contain not less than 4% butterfat and not more than 80% moisture. The standard does not specify how much of the solids and fat must come from the dressing and the curd.

Cream Cheese

Cream cheese is a soft, unripened, high-fat, lactic-type of cheese prepared from homogenized milk and cream mixture containing about 16% milk fat. A lactic acid producing bacterial culture, with or without rennet added to the mixture is held until coagulation. The coagulated mass is drained from the whey by centrifugal separators or by muslin bags. Federal standards require a minimum of 33% milk fat and a maximum of 55% moisture (FDA. 1981A). The addition of 0.5% stabilizer is allowed by standards to prevent whey leakage.

Limburger

Limburger is a semi-soft, surface-ripened variety of cheese usually made from cow's milk. It originated in the Province of Luttich, Belgium, and is named after the town Limburg, where originally much of the cheese was marketed. According to some authorities, surface organisms are responsible for its characteristic flavor and aroma which develops after two months of ripening. Yeast predominates at first, and reduces the acidity of the cheese; this is followed by growth of Brevibacterium linens with production of a characteristic reddish-yellow pigment (USDA. 1978). During ripening there is extensive protein decomposition accompanied by a strong odor and flavor.

Feta

Feta cheese is a white, soft, brine-ripened ("pickled") variety, usually made from ewe's and goat's milk. Although it originated in Greece, a Bulgarian type feta, and Egyptian domiati, and a feta made in the United States with cow's milk have similar compositions and properties. Lactic acid bacteria and rennet are used to produce the feta curd. After the curd is cut, drained, matted, milled, and heavily salted, it is molded and ripened in brine about one month before eating. Lloyd et al. (1979) described ripened feta as soft, short, but not crumbly with few fermentation holes and a fresh acid and clean salty flavor. Karlikanova et al. (1978) studied seven salt-resistant strains of streptococci in an attempt to increase and improve flavor of feta cheese. Denkov and Kr"stev (1970) proposed that farmakhim, a dried rennin/pepsin mixture from Bulgaria could be used in place of rennin to increase yield by increasing moisture 0.2%.

Camambert

Camembert cheese is a soft cheese ripened by surface molds. It was first made by Marie Fontaine of Camembert and named by Napoleon. Its interior has a distinctive characteristically yellow, waxy, creamy, or almost fluid consistency, depending upon the degree of ripening. Its exterior is a thin, gel-like layer of gray mold and dry cheese interspersed with patches of reddish

yellow (USDA. 1978). Ripening results from the growth of mold Penicillium camemberti, yeast and Brevibacterium linens, which also grow in association with the mold for secondary fermentation and provide the color change. Hydrolysis of casein and increase in H_2O soluble proteins accompany softening of the cheese. The body-texture and flavor characteristics are evident in four to five weeks.

Brick

Brick cheese is a semi-soft cheese ripened with surface growth and one of the few cheeses of American origin. It is known for its semi-soft, sweet-curd and milk but rather pungent, sweet flavor. The flavor is intermediate between cheddar and Limburger, not so sharp as cheddar nor so strong as Limburger. The body is soft and firm enough to slice without being crumbly. It has an open structure with several round and irregular holes. The name might have been derived from its brick shape or perhaps from bricks used to press the curds (USDA. 1978). The surface growth of yeast and Brevibacterium linens is presponsible for its flavor. The ripening process takes two to three months and involves relatively little proteolysis.

Blue-Veined Cheese

Blue-veined cheese is a semi-soft, mold-ripened cheese made

from cow's milk in the United States. Throughout the world it is known by various names, such as the French Bleu and Roquefort, Italian Gorganozola, American Blue, Danish Blue, and English Stilton (Kosikowski. 1978A). Each differs slightly in characteristics as well as in manufacturing process but basically all are internally mold-ripened cheeses. Ripening blue-vein cheese by the mold Penicillium roqueforti is a highly complex process that usually requires 16 to 18 weeks. The name "Roqueforti" is officially limited to the original blue-veined cheese manufactured from sheep's milk in a small area near Roquefort in south-eastern France. The growth of the mold P. roqueforti and its subsequent metabolic activity are mainly responsible fro ripening and characteristic flavor development.

A water suspension of mold spores is either added to the milk before setting or the spores are dusted on to the curds. The inoculated curd is incubated for four weeks, then surface slime is scrubbed off. Surface slime organisms are proteolytic and may contribute to flavor production. Curing continues after the cheese is punctured with slender needles to make air available for mold growth for about 16 to 18 weeks. During curing the lipolytic activity of P. roqueforti breaks down cheese fat to provide free fatty acids and methyl ketones, which are responsible for the aroma and flavor of blue-vein cheese. The organism also is the main contributor to the proteolytic breakdown for the development

of a soft, smooth, full-flavored cheese (Kinsella and Hwang (1976). Coghill (1979) reported that homogenizing milk for blue-veined cheese manufacture increases the rate of flavor development, produces a lighter colored product, accelerates fat hydrolysis, and accelerates ripening.

Cheddar

Cheddar cheese originated in a little village in Cheddar, England. It was previously made with stirred curd product without matting (Kosikowski. 1978A).

Cheddar is a hard, closed-textured, bacteria-ripened cheese that requires several months curing at about 10^{o}C to develop its characteristic flavor. Rennet and a lactic culture are used with whole milk to form curds that are warmed and pressed. Cheddaring is an important step in the manufacturing process. It involves piling and repiling of the warm curds, to increase lactic acid production that contributes to destruction of coliform bacteria. The milk for Cheddar often is standardized to a definite fat-to-casein ratio. The starter organisms are primarily responsible for the ripening and characteristic milk flavor. During the ripening, part of the casein is converted to water-soluble proteoses, peptones, and amino acids. The firm structure becomes more integrated, softer, and smoother as the flavor develops. Good quality cheddar cheese is matured at 2 to 16^{o}C at 85%

relative humidity. Most cheddar cheese is ripened at 4°C for 4 to 12 months. In Canada the curing time may be extended to 24 months (Kosikowski. 1978A). Storage at 3°C effectively prolongs the "usuable mature life" of good quality cheese after initial high (10°C) curing temperature. Gripon et al. (1977) concluded that adding microbial enzymes to cheese curds improves quality and hastens ripening. But the types and optimum amounts of enzymes to be added to produce the fine flavor are still in question.

Swiss

The manufacturing process of Swiss cheese was developed in Switzerland's Emmental Valley, hence the name Emmentaler cheese (known as Swiss cheese in the U.S.). It is hard, pressed-curd cheese with an elastic body, and a milk, nut-like sweetish flavor. Swiss cheese is best known for the large holes or eyes that develop in the curd as the cheese ripens. Streptococcus thermophilus and Lactobacillus bulgaricus or Lactobacillus lactis are used for acid production, which aids in expelling whey from the curd, whereas Propionibacterium shermanii is largely responsible for the characteristic sweet flavor and eye formation.

To increase curd elasticity and improve eye formation, milk used to produce Swiss cheese must be clarified. Standardization of fat content of the milk after clarification assures uniform

composition. Rennet and lactic acid from the bacteria cause the casein coagulation. Swiss cheeses made in the U.S. are cured three to four months (two months minimum). Cheeses made in Switzerland, however, are cured to ten months and have more pronounced flavor (USDA. 1978).

Pasta Filata (Kosikowski. 1978A)

Pasta Filata or pulled curd is one category of cheeses. At optimum pH, the curd of this cheese is heated, stretched, and molded into the desired form under water, and then the cheese is salted. There are two types of Pasta Filata cheeses the soft unripened (Mozzarella) and hard ripened (Provolone).

Mozzarella

Mozzarella is an Italian cheese variety which was traditionally made from highfat milk of the water buffalo. In southern Italy the water buffalo still supplies milk for this type of cheese. In the United States, however, it is produced from whole or partly skimmed milk. Small amounts of starter or organic acids followed by rennet extract are added. The curd formed is not cooked but simply cut and the whey is drained. The matted curds are formed into block, drained, and under warm temperatures undergo milk acid ripening at pH 5.2 to 5.4. At a "critical" pH or acidity, the curd is heated in water, stretched or mixed, molded,

placed in proper forms and slightly salted. Artificial flavor and flavor-producing enzymes normally are not added to Mozzarella cheeses (Kosikowski. 1978A).

Mozzarella accounted for 17.3 percent of the total cheese production in the United States in 1980 (USDA. 1981A).

Provolone

Provolone is an Italian, plastic curd cheese that originated from Southern Italy. It is light in color, mellow, smooth with a hard, compact, flaky, thread-like texture that slices without crumbling and with a milk, agreeable flavor. Stringy textured cheeses are made by cooking the curds at a realtively high temperature and molding them while hot into various shapes. Provolone represents the group of acid-bacteria ripened cheeses that are cooked at a relatively high temperature. The curds are kneaded and stretched until they are shiny, smooth, and elastic before being molded into various shapes. The curds then are chilled, salted in brine, smoked, waxed, and ripened like Cheddar. The typical flavor stems from the lipolysis of milkfat brought about by added special mammalian lipases.

Parmesan

Parmesan or Grana is the name commonly used inside and outside Italy for a group of very hard bacteria-ripened granular-

textured cheeses made from partially skimmed cow's milk. They originated near Parma, near Emilia, Italy, hence the name. Special lipolytic enzymes derived from animals are used, in addition to rennet, to produce the characteristic rancid flavor.

Starter culture of heat-resistant lactobacilli and Streptococcus thermophilus are added along with rennet to form the curds. Manufacture and salting of the cheeses take about 40 days. They are then stored in cool-ventilated rooms to ripen in one or two years. A fully cured Parmesan keeps indefinitely, is very hard, thus grates easily, and is used for seasoning. Low moisture and lowfat contents contribute to its hardness.

Parmesan cheese made in the United States is cured at least 14 months.

Skim milk or Low-fat Cheeses

Sapsago is chiefly manufactured in Switzerland and made from slightly soured skim milk. It is a small, very dry and hard, cone-shaped cheese. Powdered clover leaves are added to the curds to give a sharp, pungent flavor, pleasing aroma, and a light-green or sage-green color. Fully cured Sapsago dry cheese is used for grating. In contrast, Euda cheese developed by the U.S. Department of Agriculture is a ripened, low-fat semi-soft, skim milk cheese. It has a milk flavor and a soft body resembling Colby cheese in appearance. Lactic acid bacteria are responsible

for ripening. Predevelopment of lipolysis in the small amount of milk fat used contributes much of this cheese flavor.

Ricotta

After most cheese are manufactured, about 50% of the milk solids (most of the lactose and lactalbumin) remains in the whey. Cheese-like products can be made from these residual solids. One of two methods commonly used to make these whey cheeses is to concentrate the whey through evaporation with heat to obtain a firm, sugary consistency that, when cooled, forms a cheese (Primost and Ghetost). The other method is employed in the manufacture of Ricotta cheese.

Ricotta is made from coagulable constituents (principally albumin) in the whey from cheese-like Cheddar, Swiss, and Provolone; hence, it also is known as whey cheese or albumin cheese. Ricotta is a soft, bland, semi-sweet cheese that originated in Italy. All of the fat of the milk is usually left in the whey in the manufacture of Ricotta cheese. Also about 5 to 10% of whole or skim milk is added to the whey when making Ricotta in the United States. Whole milk is added if fresh Ricotta is to be produced, while skim milk is used to produce dry Ricotta, which is usually used for grating. Incorporating fat in the cheese with coagulable albumin improves its body, flavor, and food value. The milk and whey proteins are coagulated by acid (lactic or acetic)

and high heat (80 to 100°C). Fresh Ricotta has a bland flavor and a body resembling cottage cheeses in consistency. No. U.S. federal standards exist for Ricotta cheese; however, some states require that it be made from whole milk, have a minimum of 11% fat and a maximum of 80% moisture.

Processed Cheese, Cheese Foods and Spreads

The first soft process was patented in 1899. In 1916, Kraft was issued a patent for heating natural cheddar cheese and its emulsification with alkaline salts. This was the beginning of process cheese industry in the United States (Kosikowski. 1978A).

Pasteurized process cheese is made by changing the physical state of one or more varieties of cheese by comminuting and blending them with the aid of heat and a suitable emulsifying agent into a homogenous plastic mass. Heating the cheese above pasteurization temperature stops ripening and destroys most bacteria. The high temperature and a slow cooling period aid in producing a sterile product. Process cheese which contains only cheddar cheese is called "Pasteurized Process Cheddar Cheese." Among various process cheeses available, some are fabricated from a single variety of cheese while others may be blends of two or more. As a general rule the milk fat in process cheese is the same as that of the type of cheese used when only one variety of cheese is used or an average of the milk fats of the cheeses

used when more than one variety is used. Moisture concentrations in process cheese is usually not more than 1% above that of the "parent" cheese or 1% above the average moisture level when more than one cheese is used. Formulation of a typical cheese spread is presented by Kosikowski (1978A). Legal requirements for the various process cheese, cheese foods and cheese spreads are covered in the Code of Federal Regulations (FDA. 1981A), and since there are a number of exceptions to the general rules for composition of milk fat and moisture described above, those interested in legal requirements are advised to refer to the CFR.

Pasteurized Processed Cheese Foods are softer and may contain optional ingredients not permitted in processed chees, including skim milk, cream, cheese whey, lactalbumin, albumin from cheese whey. Emulsifiers, acidifying agents, water, salt, coloring agents, fruits, vegetables, spices and flavorings may also be added. Salts act principally as a taste modifier rather than an inhibitor of microbial growth in process cheese. If whey is added to process cheese, it is generally in the dried form.

Pasteurized process cheese spread may contain the same optional ingredients as cheese foods, but may contain additional moisture and stabilizing agents such as gums, gelatin and algin.

A cheese-like spread is prepared by combining hydrolyzed Swiss- or Cheddar-whey protein and culture cream. The whey protein is precipitated by heat and acid. The granular chalky

precipitate is then converted to a smooth texture by enzymatic hydrolysis with Rhozyme P-11 at 39.5 to 40.5°C for 30 minutes. The product is heated to 85°C for 15 minutes to inactivate enzymes, then it is homogenized and blended with equal quantity of 45% cream culture containing L. casei (Webb and Whittier 1970).

FROZEN DESSERTS

Frozen desserts containing milk products include ice cream and frozen custard, ice milk, sherbet and mellorine. A brief description of each of these products is presented here. A full chapter in the previous edition of this text is devoted to frozen desserts and their properties, composition and technology (Keeney and Kroger 1974).

Ice Cream

The most popular of all frozen desserts in the United States is ice cream. In a survey of selected supermarket products in 1979, more than 86% of the households involved reported using ice cream or ice milk during a 30-day period. The per capita production here was 14.6 quarts in 1980, as well as 5.15 quarts of ice milk, 0.8 quarts of sherbet and 0.2 quarts of mellorine. Several countries throughout the world, such as New Zealand, Australia and Canada, have per capita productions comparable to

that in the United States (International Association of Ice Cream Manufacturers 1981).

By definition, ice cream is a frozen food product made from a mixture of dairy ingredients such as milk, cream, and nonfat milk, that are blended with sugar, flavoring, fruit and nuts. It contains a minimum of 10% milk fat and weighs not less than 4.5 pounds per gallon.

Table 2.7 gives the principal U.S. standards for ice cream and other frozen desserts containing milk products.

Ice Milk

Ice milk is a frozen dessert similar to ice cream, except it contains 2 to 7% milk fat and about 20% less calories. There was a substantial increase in utilization of ice milk in the United States between 1955 and 1970 when per capita production increased from 2.2 to 5.6 quarts, but after 1970 there has been little change and in fact a slight decrease to 5.15 quarts per capita in 1980. Only a few of 56 countries surveyed by the International Association of Ice Cream Manufacturers (1981) reported appreciable per capita production of ice milk.

United States federal standards for plain and bulky flavored ice milk are shown in Table 2.7.

TABLE 2. 7 Selected federal standards for frozen desserts (Tobias and Muck 1981)[1]

Product	Weight (lb/gal)	Total food solids (lb/gal)	Total milk solids (%)[2]	Milk fat (%)	Whey solids (%)[3]	Egg yolk solids (%)
Ice cream	>4.5	>1.6	>20	>10	<2.5	<1.4
Bulky flavored ice cream	>4.5	>1.6	>16	>8	<2.0	<1.4
Frozen custard[4]	>4.5	>1.6	>20	>10	<2.5	>1.4
Mellorine	>4.5	>1.6	--[6,8]	--[7]	--[8]	--[5]
Ice milk	>4.5	>1.3	>11	>2	<2.25	--[5]
Ice milk	>4.5	>1.3	>11	<7	<1.0	--[5]
Bulky flavored ice milk	>4.5	>1.3	>9	>2	<1.75	--[5]
Sherbet	>6.0	--[6]	2 to 5	1 to 2	0 to 4	--[5]

[1] Reprinted with permission from the American Dairy Science Association.

[2] Caseinates may not be used to satisfy any part of the total milk solids requirement. Increases in milk fat may be offset with corresponding decreases in nonfat milk solids, but the latter must be at least 6% in frozen custard and ice cream and 4% in ice milk. Corresponding adjustments may be made in bulky flavored products.

[3] Solids from concentrated or dried whey may not exceed 25% of the nonfat milk solids.

[4] Also designated French Ice Cream or French Custard Ice Cream.

[5] Permitted.

[6] No standard.

[7] Milk fat replaced by a minimum of 6% vegetable or animal fat.

[8] At least 2.7% milk derived protein having a protein efficiency ratio (PER) not less than that of whole milk protein, 108% of casein.

Sherbets

Frozen desserts that are flavored with fruits or with flavors other than fruit and contain 1 to 2% milk fat are known as sherbets. Federal standards for these products are included in Table 2.7.

Mellorine

This food is similar to ice milk in which the milk fat is between 1 and 2% and the product weighs not less than six pounds per gallon. As a filled dairy product it is illegal in those states which still have Filled Milk laws. Its utilization has declined from about a quart per capita in 1970 to 0.2 quart in 1980.

Tabl 2.7 presents federal standards for Mellorine.

CASEIN

Commercial casein is usually manufactured from skim milk by precipitating the casein through acidification or rennet coagulation. Casein exists in milk as a calcium caseinate-calcium phosphate complex. When acid is added, the complex is dissociated, and, at pH 4.7, the isoelectric point of casein, maximum prescipitation occurs. Relatively little commercial casein is produced in the United States, but imports amounted to well over 150 million pounds in 1981 (USDA. 1981C). Casein is widely used in food products as a protein supplement. Industrial uses include paper coatings, glues, plastics and man-made fibers. Casein is typed

according to the process used to precipitate it from milk, such as hydrochloric acid casein, sulfuric acid casein, lactic acid casein, co-precipitated casein, rennet casein and low-viscosity casein. Differences in composition of casein are mostly by differences in the manufacturing process and the care taken in precipitation and washing.

The United States standards for grades of edible dry casein (acid) are presented in Title 7, Chapter 28 of the Code of Federal Regulation (FDA. 1981B) with the following specifications: Grades are determined on the basis of flavor and odor, physical appearance, bacterial estimates (standard plate count and coliform), protein content, moisture content, milk fat content, extraneous material, and free acid.

	Extra grade	Standard grade
Moisture (not more than)	10%	12%
Milk fat (not more than)	1.5%	2%
Protein (not less than)	95%	90%
Ash (not more than)	2.2%	2.2%
Free acid (not more than)	0.20 ml of 0.1 N NaOH/g	0.27 ml of 0.1 N NaOH/g
Bacterial estimates		
SPC (not more than)	30,000/g	100,000/g
coliform	neg./0.1g	2/0.1g

	Extra grade	Standard grade
Flavor and odor	Bland natural flavor and odor & free from offensive flavors & odors	Not more than slight unnatural flavors & odors, free from offensive flavors & odors.
Physical appearances	White to cream colored; if pulverized, free from lumps that do not break up under slight pressure (Extra grade); moderate pressure (Standard grade)	

Edible dry casein (acid) that fails to meet the requirements of U.S. Standard Grade, or are Salmonella or coagulase positive (Staphylococcus), are considered unsuitable for human food are not assigned a U.S. grade.

Australian standards have been established for both acid and rennet caseins. The standards for acid casein are much the same as those for United States casein. Rennet casein usually has between 7.0 and 8.3% ash compared with 2.2% for acid casein. The fact that rennet casein is essentially a calcium caseinate accounts for this comparatively large ash value.

Sodium Caseinate

Sodium caseinate, edible grade, is made from isoelectric casein which has been prepared to meet the sanitary standards for edible casein. Casein is solubilized with food-grade caustic soda and the resulting soluble product (20 to 25% solids) is spray-dried. Spray-drying procedures are adjusted to obtain a product

with 5% or less moisture content. Dry sodium caseinate usually contains about 90 to 94% protein, 3 to 5% moisture, 6 to 7% ash, and 0.7 to 1% fat. The best flavor in dried sodium caseinate is obtained when the product is made directly from fresh wet curd. The calcium and lactose content and moisture in fresh curd should be as low as possible, since all three adversely affect the resulting dried product. Isoelectric casein usually has better keeping qualitites than sodium caseinate. The uses for sodium caseinate are much the same as those of commercial casein. Increasing quantities of sodium caseinate are being used as a protein supplement in dietetic and bakery products, in stews, soup, and imitation milk.

LACTOSE

Lactose is the characteristic carbohydrate of milk, averaging about 4.9% for fluid whole cow's milk and 4.8% for sheep and goat's milk. The commercial source of lactose today is almost exclusively from sweet whey, a by-product of cheese making. Details of its production are given in Chapter 6.

Standards for anhydrous lactose are presented in Recommended International Standards For Lactose by Food and Agricultural Organization Codex Alimentarius, 1969.

Lactose anhydrous	99% min. (on dry basis)
Sulfated ash	0.3% max. (on dry basis)
Loss on drying (16 hr at 120°C)	6% max.
pH, 10% solution	4.5 - 7.0
Arsenic	1 mg/kg max.
Lead	1 mg/kg max.
Copper	2 mg/kg max.

WHEY

With the increase in production of cheese not only in the United States but throughout the world (USDA. 1981C), and more stringent controls on disposal of waste materials, the utilization of surplus cheese whey is one of the most critical problems facing the dairy industry. Whey, the liquid that remains after casein and fat are separated as curds in the cheese-making process, contains most of the salts, lactose and water soluble proteins of the milk. It varies in composition with the type of cheese from which it comes, heat treatment, handling, and other factors. The predominant type of whey is "sweet whey" which is derived from the manufacturing of ripened cheeses (Cheddar, Swiss, Provolone, etc.), so named because its pH is only slightly less than that of fresh milk. "Acid whey," on the other hand, has a pH of approximately 4.7; it is similar in composition to sweet whey except up

to 20% of the lactose is converted to lactic acid by lactose fermenting bacteria in the manufacture of products like cottage cheese. The reduced pH also may be achieved by the addition of food grade acids to replace the lactic cultures as in directly-acidified cottage cheese. Although only about 10% of the whey produced in the United States in 1980 was the acid type (Whey Products Institute 1981), it presents a serious disposal problem. "Acid whey" that results from the manufacture of cottage cheese is not of sufficient volume to make it economical to further process (concentrate or dry). On the other hand since the fluid milk plants that manufacture cottage cheese are ususally located in cities, its disposal must be accomplished in already overloaded municipal sewers. An additional complication in disposing of acid whey comes from its corrosive nature; this interferes with its subsequent processing. "Sweet Whey" from hard cheese manufacture is not hampered by these constraints.

Even though liquid whey has been successfully commercialized in the form of alcoholic and non-alcoholic beverages, these are still a rarity in most countries. Most whey is converted to whey solids as ingredients for human food or animal feeds by traditional processes such as spray drying, roller drying, concentration to semi-solid feed blocks or production of sweetened condensed whey. Jelen (1979) reported other traditionally established processes include lactose crystallization from untreated or modified

whey, production of heat-denatured whey protein concentrate, or recovery of milkfat from whey cheese in "whey butter."

Nearly 60% of the whey and whey products produced in the U.S. in 1980 were utilized in human food products and over 80% of that was as dry whey. More than 65% of the whey used for animal feed was either dry or dried whey products. Principal users of whey products for human foods are dairies and bakeries. Lactose, which is derived primarily from whey (Chapter 6), is used mainly in infant foods and pharmaceuticals (Whey Products Institute 1980).

Some limitations in the functional properties of dried whey for human foods, including high salt and lactose concentration have led to its fractionation and blending into a variety of new products. Recent developments in molecular separation techniques such as ultrafiltration, reverse osmosis, gel filtration, electodialysis and ion exchange have made possible fractionation, modification or reconstruction and blending of a variety of whey products. The Table 2.8 illustrates the type and composition of whey products currently available (Jelen 1979).

Craig (1979) has summarized the functional and nutritional properties of most of these whey-based food ingredients. A comprehensive symposium (Clark 1979) and several excellent reviews on whey and whey utilization are recommended for further studies (Clark et al. 1979).

Table 2.8

Chemical composition of selected commercial whey-based food ingredients (Jelen 1979).[1]

Product	Typical analysis			
	% Protein	% Lactose	% Ash	Source[2]
Products manufactured from whey only				
Dried sweet whey	12	74	8.5	1, 2, 4, 5, 6
Partially demineralized whey	13	75	5.5	1
Demineralized whey	14	82	0.8	1
Demineralized/delactosed whey	36	56	2.4	1
Whey protein concentrate,[2]	53	36	4.0	2, 3, 4, 5
Whey protein concentrate,[3]	85	4	1.2	4
Traditional (heated) lactalbumin	80	5	2.5	4
Blends of whey with other materials				
Whey, skim milk (and/or buttermilk)	22	54	10.0	2, 6
Whey, caseinates	34	52	8.0	2, 6
Whey, soy (and/or corn) solids	28	60[b]	8.0	2, 6
Whey, soy protein isolate	35	52	8.0	2, 6, 7

[1] Reprinted with permission from the 1982, American Chemical Society.

[2] Technical literature on which this table is based. There are other suppliers of similar products whose literature was not available. 1, Foremost Foods Co., California; 2, Dairyland Products, Minnesota; 3, Stauffer Chemical Co., Connecticut; 4, New Zealand Dairy Board, Wellington, and/or N. Z. DRI, Palmerston North; 5, Purity Cheese Co., Wisconsin; 6, Land-O-Lakes Co., Minnesota; 7, Ralston-Purina, Missouri.

[3] Total carbohydrates.

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PROPERTIES AND COMPOSITION OF MILK PRODUCTS

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AN ABSTRACT OF A MASTER'S REPORT

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This report is the basis for a revision of chapter two by R. E. Hargrove and J. A. Alford in the second edition of the "Fundamentals of Dairy Chemistry." (AVI Publishing Co.). The chapter entitled "Properties and Composition of Milk Products" deals with dairy products, their description, composition, Food and Agricultural Organization/World Health Organization and United States federal standards for which their definitions as well as some recent developments are discussed.

Milk is a very complex substance with a nutritionally balanced proportion of proteins, fats, carbohydrates, minerals and water. An alteration of this balance or removal of one or more of the milk constituents is the principle behind the manufacture of the various dairy products. A major portion of the milk supply in the United States is consumed as fluid milk. Fluid milk may be whole lowfat skim, low sodium or the relatively new product, UHT sterile aseptically packaged milk. Consumption of UHT sterile milk has increased dramatically in several European countries and has recently been introduced into Canada and the United States. Fluid milk is not only consumed plain but can be flavored with chocolate or by the addition of egg yolk as in egg nog. The most common difference in the composition of these fluids is variations in milk fat content.

Fermented and acidified milks are among the most diversified of the dairy products. Fermentation of milk is usually carried out by selected strains of lactic acid producing organisms,

whereas the acidified milk products are produced by the addition of food grade acids, to obtain a desired acidity. These products include the cultured and acidified buttermilk, sour cream, yoghurt, acidophilus and sweet acidophilus milk, kefir, and kumiss. The consumption of yoghurt in the United States has increase more rapidly than any other dairy product. This may be due in part, to the large variety of yoghurt products on the market. In addition to plain or natural yoghurt, other types such as fruit, pasteurized/UHT, concentrated, dried, low-calorie and low-lactose yoghurt have found their way to the market place and consumers acceptance. Concentrated fermented products also available in the market are the Ymer and the Lactofil.

The removal of a portion of skim milk from milk produces a product referred to as fluid cream. Various creams are classified according to their fat concentrations; products like half and half, table creams, and whipping creams.

Churning or destabilizing the emulsion of heavy creams is used to produce high fat products like butter, butter oil and ghee. There are also butter-like products produced with lesser milk fat like "Butterine" and lower-calorie spreads such as "Dairy or Dari Spread."

The removal of water from milk under vacuum is used to manufacture evaporated and condensed milks. Additions of a relatively high concentrations of sugar to condensed milk products as in sweetened condensed whole or sweetened condensed skim provide

protection against bacterial growth. The removal of water from milk with subsequent acid development produces a condensed skim milk, acid that is sued primarily for animal feeds and condensed buttermilk.

Evaporation of most of the water from milk products powdered products such as dried milk products like nonfat dry milk, dried whole milk, dry buttermilk, dry cream and malted milk powder.

Coagulation of the milk protein, casein, by acid from lactic organisms or food acidulants and rennet is the first step in most cheesemaking operations. There are more than 400 cheese varieties, these are classified according to texture, moisture, manner of ripening and method of manufacture. Based on their most significant and distinguishing characteristics, the following cheese represent examples of varieties classified according to moisture and manner of ripening: cottage cheese for soft unripened, lowfat; cream cheese for soft unripened, high fat; limburger for soft, ripened by bacteria and yeast; feta for soft, ripened by bacteria preserved by slat; camembert for soft, ripened by external molds; brick, semi-soft, ripened by internal bacteria with surface growth; blue-veined, semi-soft, ripened by internal mold; cheddar, hard, ripened by bacteria; swiss, hard, ripened by eye forming bacteria; provolone, Pasta Filata or plastic cheese; parmesan, very hard, ripened by bacteria; sapsago and edda, skim milk or low-fat cheese; ricotta, whey cheese, and the process cheese.

An important category of milk products is frozen desserts. These products are manufactured by blending milk and milk products with sugar, flavoring agents and stabilizers. Amon the most important of these are ice cream, frozen custard, ice milk, sherbet and mellorine.

Other important milk products include casein, used in imitation cheese, coffee whiteners, pet foods and pharmaceuticals, sodium caseinate used as protein supplement in dietetic and bakery products, and lactose, the milk sugar used in baby foods and pharmaceuticals.

One of the most important problems of the dairy industry is whey utilization because of increased cheese production. Various uses of whey and whey products are discussed.

Most milk products are regulated under federal and state standards in the United States. In addition, FAO/WHO standards are useful in international marketing of milk products. Both United States federal standards and FAO, Codex Alimentarius Commission standards are presented when available.