Dairy Ingredients for Food Processing
Chapter 1

Dairy Ingredients for Food Processing:
An Overview

Ramesh C. Chandan

Introduction

Dairy ingredients are important players in the formulation of many food products. The addition of familiar dairy ingredients, widely recognized by the consumer as “natural,” enhances the odds of success of packaged foods in the marketplace. They generally deliver a consumer-friendly label on the package.

Dairy ingredients are derived from fluid milk in the form of cream, butter, condensed milk, dry milk, cheese, and whey products (Olson and Aryana, 2008; Sodini and Tong, 2006). They provide desirable functionality to foods, such as delivery of key nutrients, water management, fat-holding capacity, emulsification capability, viscosity creation, gel formation, and foam generation. In addition, dairy-based ingredients in liquid, concentrated, or dry form confer desirable attributes of texture and flavor to dairy foods, frozen desserts, puddings, processed meat, cereal products, chocolate confections, infant formulas, and an array of dietetic as well as geriatric drinks and bars. In conventional bakery items, dairy ingredients are used in enriched breads, croissants, milk bread, cakes, cookies, and pastries. Figure 1.1 demonstrates the relationship of milk to major dairy ingredients used for food processing.

Dairy ingredients contribute several critical characteristics associated with a food product. Caseinates impart emulsifying and stabilizing ability. Whey protein concentrates and isolates give gelling properties and furnish high-quality protein (Kilara, 2008). Similarly, milk protein concentrates provide a base of dietetic products. High-heat nonfat dry milk is reputed to impart water-absorption capacity to baked goods. Lactose-containing dairy ingredients are responsible for desirable brown crust in bread and other bakery items. Enzyme-modified butter and cheese flavor concentrates are used in food products for butter and cheese carry-over. Dairy ingredients are important tools for a food developer to create certain desirable attributes in foods. An understanding of the functional properties of dairy ingredients allows food technologists to use their potential contributions to meet consumer expectations.

Consumer trends, especially in functional foods (Chandan and Shah, 2007) as well as fast and convenience foods, are shaping the development of new products in the marketplace. More recently, market opportunities have been leveraged in nutraceutical beverages for use as tools for weight management, meal replacement, and geriatric nutritional needs using fluid skim milk, nonfat dry milk, milk protein concentrate, and whey protein concentrate. In addition, coffee-based drinks have provided the consumer with a variety of nutritional and functional drinks.
In the arena of industrial ingredients, dairy plants fabricate convenient, custom-made mixes for food plants for processing of foods. Such practice is currently undertaken for the production of yogurt, ice cream, and confectionery products (Chandan and O’Rell, 2006a; Kilara and Chandan, 2008). Novel ingredients have been developed by applying membrane technology to fractionate milk and whey to enhance their performance in food products. Such ingredients furnish milk protein, milk fat, or milk minerals in food supplements. A new trend involves development of functional ingredients from whey, colostrum, and bioactive peptides from milk proteins, which possess distinct health-promoting attributes (Chandan 2007a and b). Other ingredients are specific metabolites concentrated in fermented milk or whey by the activity of specific dairy cultures. The dried fermented ingredients derived from fermented bases contain active metabolites that are used as natural preservatives to extend shelf life and safety of foods. The enzyme-
modified cheeses are cheese flavor concentrates that are widely used in the production of cheese powders, cheese sauces, and process cheese, and in the preparation of fillings for cookies and crackers.

**Variations in Milk Composition**

It is important to recognize that milk composition varies depending on the breed of the cow, intervals and stages of milking, different quarters of udder, lactation period, season, feed, nutritional level, environmental temperature, health status, age, weather, estrus cycle, gestation period, and exercise (Chandan, 2007a; Kailasapathy, 2008). The variations in major constituents of milk, namely fat, protein, lactose, and minerals, are more noticeable in milk from individual cows. In general, these variations tend to average out and display an interesting pattern in commercial milk used by processors. Nevertheless, the seasonal variations in

**Milk and Dairy Processing**

Fluid milk is a basic ingredient in dairy foods, including frozen and refrigerated desserts (Kilara and Chandan, 2008; Chandan and Kilara, 2008). Many dairy-derived ingredients for use in food processing owe their origin to milk, which is comprised of water and milk solids. Milk solids are comprised of milk fat and milk-solids-not-fat. Figure 1.2 illustrates the gross composition of milk, showing major constituents. The composition of whole milk solids and nonfat solids is shown in Table 1.1.

Accordingly, incorporation of dairy ingredients in a food adds these constituents to the overall food composition and allows a food developer to leverage their functionality and other attributes in food product development. Chemical, physical, and functional properties of milk are discussed in Chapter 2.

**Table 1.1.** Proximate composition of whole milk solids and skim milk solids.

<table>
<thead>
<tr>
<th>Component</th>
<th>Whole milk solids</th>
<th>Skim milk/ nonfat solids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat, %</td>
<td>29.36</td>
<td>1.08</td>
</tr>
<tr>
<td>Protein, casein, %</td>
<td>22.22</td>
<td>31.18</td>
</tr>
<tr>
<td>Whey protein, %</td>
<td>4.76</td>
<td>7.53</td>
</tr>
<tr>
<td>Lactose, %</td>
<td>38.10</td>
<td>52.15</td>
</tr>
<tr>
<td>Ash (minerals), %</td>
<td>5.56</td>
<td>8.06</td>
</tr>
</tbody>
</table>

**Figure 1.2.** Gross composition of pooled raw milk.
Accordingly, homogenized milk and cream appear whiter than non-homogenized counterparts. After the precipitation of casein and fat by the addition of a dilute acid or rennet, whey separates out. The whey possesses a green-yellow color due to the pigment riboflavin. The depth of color varies with the amount of fat remaining in the whey. Lack of fat globules gives skim milk a blue tinge. Physiological disturbances in the cow also make the milk bluer.

Cow’s milk contains the pigments carotene and xanthophylls, which tend to impart golden yellow color to the milk. Guernsey and Jersey breeds produce especially golden yellow milk. Milk from goats, sheep, and water buffalo tends to be much whiter in color because their milk lacks the pigments. The flavor of milk is critical to its consumer quality criterion. Flavor is an organoleptic property in which both odor and taste interact. The sweet taste of lactose is balanced against the salty taste of chloride, and both are somewhat moderated by proteins. This balance is maintained over a fairly wide range of milk composition, even when the chloride ion varies from 0.06% to 0.12%. Saltiness can be organoleptically detected in samples containing chloride ions exceeding 0.12% and it becomes marked in samples containing 0.15%. The characteristic rich flavor of dairy products may be attributed to the lactones, methyl ketones, certain aldehydes, dimethyl sulfide, and certain short-chain fatty acids. As lactation advances, lactose declines while chlorides increase, so that the balance is slanted toward “salty.” A similar dislocation is caused by mastitis and other udder disturbances. Accordingly, milk flavor is related to its lactose:chloride ratio.

Freshly drawn milk from any mammal possesses a faint odor of a natural scent peculiar to the animal. This is particularly true for the goat, mare, and cow. The cow odor of cows’ milk is variable, depending upon the individual season of the year and the hygienic conditions of milking. A strong “cowy” odor frequently observed during the winter months
may be due to the entry of acetone bodies into milk from the blood of cows suffering from ketosis.

Feed flavors in milk originate from feed aromas in the barn; for instance, aroma of silage. In addition, some feed flavors are imparted directly on their ingestion by the animal. Plants containing essential oils impart the flavor of the volatile constituent to the milk. Garlic odor and flavor in milk is detected just one minute after feeding garlic. Weed flavor of chamomile or mayweed arises from the consumption of the weed in mixtures of ryegrass and clover. Cows on fresh pasture give milk with a less well-defined “grassy” flavor, due to coumarin in the grass. A “clovery” flavor is observed when fed on clover pasture, and these taints are not perceptible when dried material is fed. Prolonged ultraviolet radiation and oxidative taints lead to “mealiness,” “oiliness,” “tallowiness,” or “cappy” odor. Traces of copper (3 ppm) exert development of metallic/oxidized taints in milk. Microbial growth in milk leads to off-flavors such as sour, bitter, and rancid. Raw milk received at the plant should not exhibit any off-flavors. Certain minor volatile flavor may volatilized off by dairy processing procedures. Various off-flavors and their origins are summarized in Table 1.2.

Table 1.2. Origins and causes of off-flavors in milk and dairy ingredients.

<table>
<thead>
<tr>
<th>Origin</th>
<th>Off-flavor</th>
<th>Description</th>
<th>Potential causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical/biochemical</td>
<td>Rancid, lipolytic</td>
<td>Soapy, bitter, unclean, blue-cheese-like aroma, strong, foul, lingering aftertaste</td>
<td>Raw milk homogenization, delay in pasteurization after homogenization, raw milk mixed with pasteurized milk</td>
</tr>
<tr>
<td></td>
<td>Oxidized, light-induced</td>
<td>Feathery, tallow, burnt, medicinal, chemical taste</td>
<td>Milk exposed to UV light (sunlight/fluorescent light in dairy cabinet)</td>
</tr>
<tr>
<td>Microbiological</td>
<td>Malty</td>
<td>Grapenut flavor, burnt, caramel</td>
<td>Equipment not properly sanitized, milk not cooled promptly to less than 10°C/50°F</td>
</tr>
<tr>
<td></td>
<td>Acid/sour</td>
<td>Tingling/peeling sensation on tongue</td>
<td>Milk stored warm for prolonged period</td>
</tr>
<tr>
<td></td>
<td>Fermented/fruity</td>
<td>Odor reminiscent of sauerkraut, vinegar, apple, pineapple, and other fruits</td>
<td>Old, refrigerated pasteurized milk, raw milk stored for prolonged time</td>
</tr>
<tr>
<td></td>
<td>Bitter/unclean</td>
<td>Persistent bitter, unpleasant, musty, stale, dirty, spoiled taste</td>
<td>Dirty utensils and equipment, temperature abuse</td>
</tr>
<tr>
<td>Absorbed during milk</td>
<td>Feed</td>
<td>Aromatic, onion, garlic, clover, reminiscent of feed</td>
<td>Feeding cows 0.5 to 3 hours before milking</td>
</tr>
<tr>
<td>production</td>
<td>Barn-like</td>
<td>Aroma of poorly maintained barn, unclean aftertaste</td>
<td>Poor barn ventilation and accumulated aromatic odors in barn</td>
</tr>
<tr>
<td></td>
<td>Cow-like</td>
<td>Reminiscent of cow breath odor; unpleasant medicinal, chemical aftertaste</td>
<td>Cows afflicted with ketosis/acetonemia</td>
</tr>
<tr>
<td>Processing induced</td>
<td>Cooked</td>
<td>Scorched, sulfur-like, caramelized, sweet flavor</td>
<td>Pasteurization time and temperatures exceeding normal parameters, heat-sterilized milk</td>
</tr>
<tr>
<td></td>
<td>Flat</td>
<td>Lacking full flavor, no flavor</td>
<td>Low total solids content, watered milk</td>
</tr>
<tr>
<td></td>
<td>Foreign</td>
<td>Flavor and aroma not typical of milk</td>
<td>Contamination with cleaning and sanitary chemicals</td>
</tr>
</tbody>
</table>

Adapted from Chandan (1997, 2007a)
Raw Milk Quality Specifications

It is essential to set up stringent specifications for quality maintenance for purchasing milk. The specifications involve several parameters as discussed below.

**Standard plate count (SPC)** is a measure of the total bacteria count, and measures the overall microbiological quality of milk. High SPC can cause reduced shelf life of the finished product and off flavors from enzyme activity and elevated acidity.

Per Pasteurized Milk Ordinance (USDHHS PMO, 2003), the U.S. Federal Grade A Standards allow a maximum of 100,000 CFU/ml for an individual producer and 300,000 CFU in commingled milk. However, some states differ. For example, for an individual producer, the Idaho standard is 80,000 CFU/ml maximum and the California standard is 50,000 CFU/ml maximum. It is recommended to set the standard at 50,000 CFU/ml.

**Coliform bacteria count** is a measure of milk sanitation. High coliform counts reflect poor milking practices and unsatisfactory cleanliness of the dairy operation. Occasionally, coliform count may indicate sick cows in smaller herds. Coliform count is an indicator that food poisoning organisms may be present. There are no federal standards for coliform counts in raw milk, but California has a standard for coliform (750 CFU/ml maximum). A recommended standard is 500 CFU/ml.

**Laboratory pasteurized count (LPC)** is a measure of heat-stable bacteria that may survive pasteurization. It is performed by heat-treating laboratory samples to simulate batch pasteurization at 62.8°C (145°F) for 30 minutes and enumerating the bacteria that survive using the SPC method. High LPC results indicate potential contamination from soil and dirty equipment at the dairy. High LPC causes reduced shelf life of finished products. *Bacillus cereus* is a common soil microorganism that can survive pasteurization, resulting in a high LPC. There are no federal standards for LPC. However, the California standard for LPC is 750 CFU/ml maximum. A recommended standard is 500 CFU/ml.

**Preliminary incubation (PI) count** is a measure of bacteria that will grow in refrigerated conditions. The test requires holding the sample at 10°C (50°F) for 18 hours followed by a SPC test. PI type of bacteria are destroyed by pasteurization but can still result in lower quality milk due to enzymatic activity on the protein. High PIs (3- to 4-fold higher than SPCs) are generally associated with inadequate cleaning and sanitizing of either the milking system or cows and/or poor milk cooling.

There are no federal standards for PI counts in raw milk. Because the type of bacteria and the initial count of the SPC may vary, it is not possible to set a numerical standard for this test. A recommended standard is less than two times the SPC count.

**Somatic cell count (SCC)** is a measure of the white blood cells in the milk. It is used as an indicator of herd health. High SCCs are undesirable because the yield of all cultured products is proportionally reduced, the flavor becomes salty, development of oxidation increases, and it usually relates to higher SPC. Staphylococci and streptococci are heat-tolerant bacteria that normally cause mastitis. Coliform bacteria, which are easily killed by heat, may cause mastitis. The PMO standards allow individual milk not to exceed 750,000 cells/ml. State standards vary. For example, the California standard is 600,000 cells/ml maximum. A recommended standard is 500,000 cells/ml.

**Titratable acidity (TA)** is a measure of the lactic acid content of milk. High bacteria counts produce elevated lactic acid levels as the bacteria ferment lactose. The normal range of TA in fresh milk is 0.13% to 0.16%. Elevated temperatures for an extended time allow the bacteria to grow and generate a higher TA value. Lower values...
may indicate the presence of chemicals in
the milk. A recommended standard is 0.13%
to 0.17% TA.

**Temperature** According to the PMO
standard, the temperature of milk must never
exceed 7°C (45°F). A recommended standard
is 5°C (40°F) or less.

**Flavor** is an important indicator of quality,
as stated earlier. The milk should be fresh and
clean with a creamy appearance. Elevated
bacteria counts can produce off-flavors (for
example, acid, bitter). Feed flavors may vary
from sweet to bitter and indicate the last
items in a cow’s diet, such as poor feed,
weeds, onion, or silage. Elevated somatic cell
counts make milk taste salty and watery.
Water in the milk gives it a watery taste.
Dirty, “barny,” and “cowy” flavors occur
from sanitation conditions and air quality at
the dairy farm. Oxidized or rancid flavors
occur from equipment operation and
handling.

There are no federal standards for flavor.
All receiving plants should favor milk for
defects before accepting it.

A recommended standard is that no off-
flavor exists.

**Appearance** is not a measured criterion
but for indications of quality it is as important
as flavor. There are no federal standards for
appearance. Most receiving plants must note
any color or debris defect in the milk before
accepting it. A recommended standard is
“White, clean, no debris, and filter screen of
2 or less (sediment test).”

**Antibiotics and other drugs** may not be
present in milk. All raw milk must conform
to the PMO Grade A regulations (Frye, 2006).
To be considered organic, no milk can be
used from a cow that has been treated with
antibiotics without a 12-month holding
period following treatment. For conventional
milk, a treated cow will be withheld from the
milking herd for about 5 days.

**Added water** is an adulteration. Testing
the freezing point of milk using a cyroscope
indicates if abnormal amounts of water exist
in the load. In most states it is illegal to have
a freezing point above −0.530° Hortvet scale.
A recommended standard should be −0.530°
Hortvet or less.

**Sediment** is measured by drawing 1 pint
of sample through a cotton disk and assigning
a grade of 1 (good) to 4 (bad) to the filter.
A grade of 1 or 2 is acceptable. A processor
also may monitor for sediment by screening
the entire load through a 3-inch mesh filter at
the receiving line. There are no federal stan-
dards. Most receiving plants should require a
filter grade of 1 or 2, although a 3 may be
accepted.

A recommended standard is “No exces-
sive material in a 3-inch sani-guide filter.”

**Fat and milk-solids-not-fat (MSNF)**
have FDA standards of identity for milk of
3.25% fat and 8.25% MSNF. This is the re-
commended standard.

In the recent past, major advances in dairy
processing have resulted in improvement in
safety and quality of products. In particular,
ultra-pasteurization techniques and aseptic
packaging systems have presented the indus-
trial user with extended and long shelf-life
products.

**Basic Steps in Milk Processing**

It is beneficial for food developers and pro-
cessors to know the basic steps involved in
dairy processing. A detailed description of
basic dairy processing is given in Chapter 4.
Milk production, transportation, and process-
ing are regulated by Grade A Pasteurized
Milk Ordinance (USDHHS PMO, 2003; Frye
and Kilara, 2006). Chapter 15 of this book
deals with the regulatory aspects of dairy-
based ingredients. Figure 1.3 shows the
journey of milk from the farm to supermar-
ket, including processing at the milk plant.

**Bulk Milk Handling and Storage**

The handling and storage of bulk milk are
key components of good quality milk. Dairy
farms produce sanitary raw milk under the supervision of U.S. Public Health Services (Pasteurized Milk Ordinance). The regulations help in the movement of assured quality milk across interstate lines.

Today, virtually all the raw milk at the plant is delivered in tank trucks. Unloading of milk involves agitation of the truck, inspection for the presence of off-flavors, collection of a representative sample, and connection of the unloading hose to the truck outlet. After opening the tank valve, a high-capacity transfer pump is used to pump milk to a storage tank or silo. The weight of milk transferred is registered with a meter or load cells. The tank truck is then cleaned by plant personnel by rinsing with water, cleaning with detergent solution, rinsing again with water, and finishing with a chlorine/iodine sanitizing treatment. A clean-in-place line
Dairy Ingredients for Food Processing: An Overview

11

milk should normally contain 0.01% fat or less. A standardization valve on the separator permits the operator to obtain separated milk of a predetermined fat content. Increased back pressure on the cream discharge port increases the fat content in standardized milk. By blending cream and skim milk fractions, various fluid milk and cream products of required milk fat content can be produced.

Heat Treatment

The main purpose of heat treatment of milk is to kill 100% of the disease-producing (pathogenic) organisms and to enhance its shelf life by removing approximately 95% of all the contaminating organisms. Heat treatment is an integral part of all processes used in dairy manufacturing plants. Intensive heat treatment brings about interactions of certain amino acids with lactose, resulting in color changes in milk (Maillard browning) as observed in sterilized milk and evaporated milk products.

Among milk proteins, caseins are relatively stable to heat effects. Whey proteins tend to denature progressively by severity of heat treatment, reaching 100% denaturation at 100°C (212°F). In the presence of casein, denatured whey proteins complex with casein, and no precipitation is observed in milk. In contrast to milk, whey that lacks casein, and heat treatment at 75°C to 80°C (167°F to 176°F) results in precipitation of the whey proteins.

From a consumer standpoint, heat treatment of milk generates several sensory changes (cooked flavor) depending on the intensity of heat. In general, pasteurized milk possesses the most acceptable flavor. Ultra-pasteurized milk and ultra-high-temperature (UHT) milk exhibit a slightly cooked flavor. Sterilized milk and evaporated milk possess a pronounced cooked flavor and off-color.

The U.S. Food and Drug Administration (PMO) has defined pasteurization time and
temperature for various products. The process is regulated to assure public health. Milk is pasteurized using plate heat exchangers with a regeneration system. The process of pasteurization involves heating every particle of milk or milk product in properly designed and operated equipment to a prescribed temperature and holding it continuously at or above that temperature for at least the corresponding specified time. Minimum time-temperature requirements for pasteurization are based on thermal death time studies on the most resistant pathogen that might be transmitted through milk. Table 1.3 gives the various time-temperature requirements for legal pasteurization of dairy products.

Most refrigerated cream products are now ultra-pasteurized by heating to 125°C to 137.8°C (257°F to 280°F) for two to five seconds and packaged in sterilized cartons in clean atmosphere. For ambient storage, milk is UHT treated at 135°C to 148.9°C (275°F to 300°F) for four to 15 seconds, followed by aseptic packaging. In some countries, sterilized/canned milk is produced by a sterilizing treatment of 115.6°C (240°F) for 20 minute. It has a light brown color and a pronounced caramelized flavor.

Homogenization

Homogenization reduces the size of fat globules of milk by pumping milk at high pressure through a small orifice, called a valve. The device for size reduction, the homogenizer, subjects fat particles to a combination of turbulence and cavitation. Homogenization is carried out at temperatures higher than 37°C (99°F). The process causes splitting of original fat globules (average diameter approximately 3.5μm) into a very large number of much smaller fat globules (average size less than 1μm). As a consequence, a significant increase in surface area is generated. The surface of the newly generated fat globules is then covered by a new membrane formed from milk proteins. Thus, the presence of a minimum value of 0.2 g of casein/g fat is desirable to coat the newly generated surface area. As milk is pumped under high pressure conditions, the pressure drops, causing breakup of fat particles.

If the pressure drop is engineered over a single valve, the homogenizer is deemed to be a single-stage homogenizer. It works well with low-fat products or in products in which high viscosity is desired, as in cream and sour cream manufacture. On the other hand, homogenizers that reduce fat globule size in two stages are called dual-stage homogenizers. In the first stage the product is subjected to high pressure (for example, 13.8 Mpa, 2,000 psi) which results in breakdown of the particle size diameter to an average of less than 1μm. Then the product goes through the second stage of 3.5 MPa (500 psi) to break the clusters of globules formed in the first stage. Dual stage homogenization is appropriate for fluids with high fat and solids-not-fat content or whenever low viscosity is needed.

Homogenized milk does not form a cream layer (creaming) on storage. It displays a whiter color and fuller body and flavor characteristics. Homogenization leads to better viscosity and stability by fully dispersing stabilizers and other ingredients in ice cream, cultured products, and other formulated dairy products.

Cooling, Packaging, and Storage

Pasteurized fluid milk products are rapidly cooled to less than 4.4°C (40°F), packaged in appropriate plastic bottles/paper cartons, and stored in cold refrigerated rooms for delivery to grocery stores or warehouses for distribution.

Fluid Milk Products

Commercial milk is available in various milk fat contents. The approximate composition of fluid milk products is shown in Table 1.4. The
Table 1.3. Minimum time-temperature requirements for legal pasteurization in dairy operations.

<table>
<thead>
<tr>
<th>Process</th>
<th>Milk: whole, low fat, skim/nonfat</th>
<th>Milk products with increased viscosity, added sweetener, or fat content 10% or more</th>
<th>Eggnog, frozen dessert mixes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vat (batch)</td>
<td>30 minutes at 63°C (145°F)</td>
<td>30 minutes at 66°C (150°F)</td>
<td>30 minutes at 69°C (155°F)</td>
</tr>
<tr>
<td>High temperature short time</td>
<td>15 seconds at 72°C (161°F)</td>
<td>15 seconds at 75°C (166°F)</td>
<td>25 seconds at 80°C (175°F)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>15 seconds at 83°C (180°F)</td>
</tr>
<tr>
<td>Higher heat</td>
<td>1 second at 89°C (191°F)</td>
<td>1 second at 89°C (191°F)</td>
<td>1 second at 89°C (191°F)</td>
</tr>
<tr>
<td>Shorter time</td>
<td>0.5 second at 90°C (194°F)</td>
<td>0.5 second at 90°C (194°F)</td>
<td>0.5 second at 90°C (194°F)</td>
</tr>
<tr>
<td></td>
<td>0.1 second at 94°C (201°F)</td>
<td>0.1 second at 94°C (201°F)</td>
<td>0.1 second at 94°C (201°F)</td>
</tr>
<tr>
<td></td>
<td>0.05 second at 96°C (204°F)</td>
<td>0.05 second at 96°C (204°F)</td>
<td>0.05 second at 96°C (204°F)</td>
</tr>
<tr>
<td></td>
<td>0.01 second at 100°C (212°F)</td>
<td>0.01 second at 100°C (212°F)</td>
<td>0.01 second at 100°C (212°F)</td>
</tr>
<tr>
<td>Ultra pasteurized</td>
<td>2 seconds at 138°C (280.4°F)</td>
<td>2 seconds at 138°C (280.4°F)</td>
<td>2 seconds at 138°C (280.4°F)</td>
</tr>
<tr>
<td>Ultra-high temperature</td>
<td>Comply with low acid canned food regulations (21CFR 113)</td>
<td>Comply with low acid canned food regulations (21CFR 113)</td>
<td>Comply with low acid canned food regulations (21CFR 113)</td>
</tr>
<tr>
<td>(UHT), aseptic</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Adapted from Chandan (1997), Partridge (2008), USHHS FDA (2003)
been demonstrated that the shelf life is shortened to 20 days by storage at 2 °C (35.6 °F), 10 days at 4 °C (39.2 °F), 5 days at 7 °C (44.6 °F), and progressively to fewer days at higher temperatures. This illustration underscores the importance of maintaining refrigerated storage temperature as low as possible to achieve the maximum shelf life of milk.

Ultra-pasteurized products are packaged in a near-aseptic atmosphere in pre-sterilized containers and held refrigerated to achieve an extended shelf life. When an ultra-pasteurized product is packaged aseptically in a specially designed multilayer container, it displays a shelf life longer than any other packaged fluid milk and cream products. UHT products subjected to aseptic heat treatment and packaged aseptically in specially designed multilayer containers can be stored at ambient temperatures for several months.

Fluid Cream

Cream is prepared from milk by centrifugal separation. Heavy cream contains not less than 36% fat and may be called heavy whipping cream. Light whipping cream contains 30% or more milk fat, but less than 36% milk fat and may be labeled as whipping cream. Light cream, coffee cream, or table cream contains not less than 18% milk fat, but less than 30% milk fat. Half and half is normally a blend of equal proportion of milk and

### Table 1.4. Typical composition of fluid dairy ingredients.

<table>
<thead>
<tr>
<th>Dairy Ingredient</th>
<th>% Water</th>
<th>% Fat</th>
<th>% Protein</th>
<th>% Lactose</th>
<th>% Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole milk</td>
<td>87.4</td>
<td>3.8</td>
<td>3.2</td>
<td>4.9</td>
<td>0.7</td>
</tr>
<tr>
<td>Skim milk</td>
<td>90.9</td>
<td>0.1</td>
<td>3.3</td>
<td>5.0</td>
<td>0.7</td>
</tr>
<tr>
<td>Half and half</td>
<td>80.2</td>
<td>11.5</td>
<td>3.1</td>
<td>4.5</td>
<td>0.7</td>
</tr>
<tr>
<td>Light cream</td>
<td>74.0</td>
<td>18.3</td>
<td>2.9</td>
<td>4.2</td>
<td>0.6</td>
</tr>
<tr>
<td>Light whipping cream</td>
<td>62.9</td>
<td>30.5</td>
<td>2.5</td>
<td>3.6</td>
<td>0.5</td>
</tr>
<tr>
<td>Heavy whipping cream</td>
<td>57.3</td>
<td>36.8</td>
<td>2.2</td>
<td>3.2</td>
<td>0.5</td>
</tr>
<tr>
<td>Plastic cream</td>
<td>18.2</td>
<td>80.0</td>
<td>0.7</td>
<td>1.0</td>
<td>0.1</td>
</tr>
<tr>
<td>Fluid UF* whole milk</td>
<td>70–75</td>
<td>11–14</td>
<td>10–12</td>
<td>&lt;5</td>
<td>&gt;2.5</td>
</tr>
<tr>
<td>Fluid UF* skim milk</td>
<td>80–85</td>
<td>&lt;0.5</td>
<td>10–12</td>
<td>&lt;5</td>
<td>&gt;2.5</td>
</tr>
<tr>
<td>Fluid UF* skim milk, diafiltered</td>
<td>80–82</td>
<td>&lt;0.5</td>
<td>16–17</td>
<td>&lt;1</td>
<td>&gt;1.5</td>
</tr>
</tbody>
</table>

*UF, ultra-filtered
Adapted from Chandan (1997), Chandan and O’Rell (2006a)
Fat-rich Products

Butter

The manufacture of butter and spreads is discussed in another publication (Fearon and Golding, 2008) and in Chapter 9 of this book. Butter is a concentrated form of milk fat, containing at least 80% fat. It can be converted to shelf-stable products such as butter oil, anhydrous milk fat, and ghee. Table 1.5 shows the approximate composition of butter and its products.

Figure 1.5 is flow-sheet diagram for the manufacture of butter, butter oil, and certain dry milk products. The diagram also displays interrelationships between these products.
Table 1.5. Typical composition of milk fat concentrates.

<table>
<thead>
<tr>
<th>Product</th>
<th>% Water</th>
<th>% Fat</th>
<th>% Protein</th>
<th>% Lactose</th>
<th>% Ash</th>
<th>Added ingredient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butter</td>
<td>16.5</td>
<td>80.5</td>
<td>0.6</td>
<td>0.4</td>
<td>2.5</td>
<td>0–2.3% salt</td>
</tr>
<tr>
<td>Anhydrous milk fat</td>
<td>0.1</td>
<td>99.8</td>
<td>0.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Butter oil</td>
<td>0.3</td>
<td>99.6</td>
<td>0.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ghee</td>
<td>&lt;0.5</td>
<td>99–99.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Adapted from Chandan (1997), Aneja et al. (2002)

Figure 1.5. Flow sheet diagram for butter, butter oil, dry buttermilk, nonfat dry milk, and dry whole milk.
Butter is obtained by churning cream. The temperature of churning is an important parameter to follow. The churning temperature is determined by an optimum ratio of crystalline fat, solid fat, and liquid fat. The churns are either batch type or continuous type. For batch-type churns, cream of 35% to 45% fat is used. For continuous type churns, cream of 42% to 44% fat is used. Cream is pasteurized at 73.8°C (165°F) for 30 minutes or at 85°C (185°F) for 15 seconds and is then cooled to about 7°C (45°F) for crystallization of fat. The crystallization process is completed by holding the cream for approximately 16 hours.

The cream that registers an increase in temperature to 10°C (50°F) is then transferred to a sanitized churn. Annatto coloring may be incorporated, if required. The churn is continuously rotated to convert oil-in-water type of emulsion (cream) to water-in-oil type emulsion (butter). This conversion is known as phase inversion. This is accompanied by the appearance of butter granules of the size of popcorn or peas. Cream begins to foam during phase inversion. Free fat generated by rupture of fat globules of cream cements some of the remaining fat globules to form clumps or butter granules. There is a clear separation of butter granules from the surrounding liquid, called buttermilk. At this stage, the buttermilk is drained out, followed by the addition of an aliquot of clean cold water (1°C to 2°C/33.8°F to 35.6°F) to the churn. The total volume of wash water is equal to the volume of buttermilk. The washing continues until the rinse is almost clear. Salt at 1.6% level is added and blended with butter. The next step is called “working,” in which the remaining fat globules are disrupted to liberate free fat.

All of the free fat then forms the continuous phases in which water droplets are dispersed to form butter. Working of butter is accomplished by continuous rotation of the churn until the body of butter is closely knit to show a waxy character with no visible pockets of surface moisture. The working of butter is continued to standardize moisture until the fat content of butter is 80%. Butter is then pumped and packaged.

Continuous butter churns are now widely in use. They accelerate the churning process, and washing of butter is not necessary. Cream of 42% to 44% fat is introduced into a cylinder, where it is churned. Buttermilk is drained and butter granules are worked to obtain the typical waxy body and texture of butter, followed by packaging. In another process, cream is separated to get plastic cream of 80% fat. The phase inversion is carried out by chilling. The butter granules are worked to achieve typical butter body and texture.

In some countries, butter is churned from cultured cream. Cultured cream butter has a distinct flavor and can be easily distinguished from sweet cream butter.

The processing conditions affect the physical properties such as crystallization and melting behavior of butterfat. The crystal formation is mediated by nucleus formation and subsequent growth of crystals. The size of crystals depends on rate of crystallization. Melting behavior influences the application of butter in food products. The rate of transformation of solid fat fraction into liquid milk fat is important and is characterized by melting point range, thermal profile, and solid fat content. The melting point temperature is the temperature at which milk fat melts completely to a clear liquid. It occurs at a range of 32°C to 36°C (90°F to 97°F) and assumes completely liquid state at 40°C (104°F). It acquires completely solid state at −75°C (−103°F). At ambient temperature, it is a mixture of crystals and liquid phases.

By manipulating temperature, butterfat has been fractionated into three fractions exhibiting distinct functionalities. Low-melting fraction melts below 10°C (50°F), middle-melting fraction melts between 10°C and 20°C (50°F and 68°F), and high-melting fraction melts above 20°C (68°F). Low-melt fraction contains significantly lower levels of saturated fatty acids. Butter made with very low-melt fraction spreads at refrigerated
temperature. Further fractionation leads to very high-melting fraction that melts at a temperature higher than 50°C (above 122°F), behaving like cocoa butter in confectionery products.

**Light/reduced fat butter** contains 40% fat. The reduced fat form cannot be used for baking.

**Butter-vegetable oil blends** are obtained by blending certain vegetable oils such as corn oil or canola oil emulsified into cream prior to the churning process. The objective is to reduce the saturated fatty acid content to enhance the healthy perception of the product or to make the product easily spreadable at refrigeration temperature.

**Butter oil** is at least 99.6% fat and contains less than 0.3% moisture, and traces of milk solids-not-fat. Butter is melted by heating gently to break the emulsion and centrifuged in a special separator to collect milk fat, followed by vacuum drying.

**Anhydrous milk fat** or anhydrous butter oil is obtained from plastic cream of 70% to 80% fat. Phase inversion takes place in a special unit (separator) and the moisture is removed by vacuum drying. It contains at least 99.8% milk fat and no more than 0.1% moisture.

**Ghee** is another concentrated milk fat that is widely used in tropical regions of the world, especially in South Asian countries. It is a clarified butterfat obtained by desiccation of butter at 105°C to 110°C (221°F to 230°F). The intense heat treatment generates a characteristic aroma and flavor brought about by heat-induced interactions of components of milk solids of butter. The detailed manufacturing procedure for ghee is given elsewhere (Aneja et al., 2002).

**Concentrated/Condensed Fluid Milk Products**

For a detailed description of condensed milk and dry milks, see the publications of Farkye (2008) and Augustin and Clarke (2008), and Chapters 5 and 6 of this book. An outline for manufacturing dry whole milk, nonfat dry milk, and dry buttermilk powder is depicted in Figure 1.5. The functional properties of concentrated milk products including nonfat dry milk can be manipulated by specific heat treatment. It also affects the keeping quality of whole milk powder. The temperature and time combinations can vary widely depending on the required functional properties. Invariably, the milk for manufacture of concentrated milk products is pasteurized (high-temperature, short-time) by heating to at least 72°C (161°F) and holding at or above this temperature for at least 15 seconds. An equivalent temperature-time combination can be used. With condensed milk and nonfat dry milk, the extent of heat treatment can be measured by the whey protein nitrogen index, which measures the amount of undenatured whey protein.

Removal of a significant portion of water from milk yields a series of dairy ingredients. Consequently, these ingredients offer tangible savings in costs associated with storage capacity, handling, packaging, and transportation. The composition of concentrated milk products is shown in Table 1.6.

**Concentrated milk or condensed whole milk** is obtained by removing water from milk and contains at least 7.5% milk fat and 25.5% milk solids. Condensed milk is available in whole milk, low-fat, and nonfat varieties. Condensed whole milk is purchased largely by confectionary industries. It is pasteurized but not sterilized by heat. It may be homogenized and supplemented with vitamin D.

**Condensed skim milk** is commonly used as a source of milk solids in dairy applications and in the manufacture of ice cream, frozen yogurt, and other frozen desserts. Condensed milks are generally customized orders. User plants specify total solids concentration, fat level, heat treatment, and processing conditions. The dairy concentrates offer economies of transportation costs and
Dairy Ingredients for Food Processing: An Overview

than evaporated milk. Condensed milk may be low fat and nonfat. It is derived from milk after the removal of 60% of its water. It must contain at least 8% milk fat and 28% milk solids. The viscosity of the product is high, approximating 1,000 times that of milk. Sweetened condensed milk is used in confectionery manufacture as well in the manufacture of exotic pies and desserts.

Manufacture of sweetened condensed milk resembles the manufacture of condensed skim milk given above. The addition of sugar and control of lactose crystal size require special processing procedures. The standardized milk is preheated to 93.3°C (200°F) and held for 10 to 20 minutes. The objective of preheat treatment is to destroy microorganisms and enzymes and to increase heat stability of the milk. In addition, the viscosity of condensed milk is controlled by a time-temperature regime during preheat treatment. The heated milk is concentrated in energy-efficient multi-effect evaporators that operate in high vacuum condition to boil off water at moderate temperatures of 46.1°C to 54.4°C (115°F to 130°F). The concentrated milk is continuously separated from water vapor to achieve desirable concentration of milk solids. It may be homogenized prior to cooling and packaging or pumped to insulated trucks for transportation to user plants.

Sweetened condensed milk contains 60% sugar in the water phase, which imparts a preservative effect. Consequently, it has enhanced shelf life. When packaged properly, the product is stable for many months at ambient storage temperature. Because it does not need high heat treatment for sterilization, it possesses a much better color and flavor than evaporated milk. Condensed milk may be low fat and nonfat. It is derived from milk after the removal of 60% of its water. It must contain at least 8% milk fat and 28% milk solids. The viscosity of the product is high, approximating 1,000 times that of milk. Sweetened condensed milk is used in confectionery manufacture as well in the manufacture of exotic pies and desserts.

<table>
<thead>
<tr>
<th>Products</th>
<th>% Water</th>
<th>% Fat</th>
<th>% Protein</th>
<th>% Lactose</th>
<th>% Ash</th>
<th>Added ingredient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweetened condensed whole milk</td>
<td>26.1</td>
<td>8.7</td>
<td>7.9</td>
<td>11.3</td>
<td>1.8</td>
<td>44.2% sucrose</td>
</tr>
<tr>
<td>Sweetened condensed skim milk</td>
<td>28.4</td>
<td>0.3</td>
<td>10.0</td>
<td>16.3</td>
<td>2.3</td>
<td>42.7% sucrose</td>
</tr>
<tr>
<td>Condensed whole milk</td>
<td>74.5</td>
<td>7.5</td>
<td>6.2</td>
<td>9.4</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td>Condensed skim milk—medium solids</td>
<td>70.0</td>
<td>0.4</td>
<td>10.8</td>
<td>15.5</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>Condensed skim milk—high solids</td>
<td>59.9</td>
<td>0.4</td>
<td>14.4</td>
<td>22.3</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>Evaporated whole milk</td>
<td>74.0</td>
<td>7.6</td>
<td>6.8</td>
<td>10.0</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td>Evaporated low-fat milk</td>
<td>79.0</td>
<td>0.2</td>
<td>7.6</td>
<td>11.4</td>
<td>1.8</td>
<td></td>
</tr>
</tbody>
</table>

Adapted from Chandan (1997)
The lactose crystal size must be less than 10 μm to avoid settling in storage and to prevent sandiness in the product. Sweetened condensed milk is packaged in metal or plastic containers and sealed. For bulk sales, it is pumped into insulated trucks for transport and delivery to user plants.

Evaporated milk is also concentrated milk that is homogenized and heat sterilized in sealed cans or bottles. It is made by boiling off 60% of the water content of milk. It must contain at least 6.5% milk fat and 23% milk solids. Evaporated milk is heat-sterilized. The sterilization process renders the product safe for consumption and it can be stored at room temperature for several months without deterioration of flavor. The current processing trend is to subject the product to ultrahot heat treatment, followed by aseptic packaging. This process gives a product with better color and flavor than the in-can sterilized product. Typically, the concentration factor is of the order of 2.1 times, giving a milk fat level of approximately 8% and nonfat solids of approximately 18%. Low-fat evaporated milk composition is 4% fat and 20% nonfat solids, whereas nonfat evaporated milk contains 0.1% fat and 22% nonfat solids. Evaporated milk is mainly a retail canned product used by the consumer as a convenience ingredient in the preparation of meals, snacks, and desserts.

Manufacture of evaporated milk involves standardization of milk to a desired fat : nonfat solids ratio and preheating to 135°C (275°F) for 30 seconds. The milk is concentrated in a vacuum evaporator at 68.3°C to 82.2°C (155°F to 180°F) and homogenized at 65°C (14°F) and 20.7 MPa (3,000 psi), first stage, and 3.5 MPa (500 psi), second stage. It is then cooled to 10°C (50°F) and stabilized with disodium hydrogen phosphate to reduce age thickening during subsequent storage. The product is packaged in metal cans and sealed, followed by sterilization at 120°C (248°F) for 15 minutes.

In a more recent process, the product is vacuum-concentrated and stabilized with disodium hydrogen phosphate as in the conventional process. It is then sterilized at 140.6°C (285°F) for 15 seconds, cooled to 60°C (140°F), and homogenized at 41.3 MPa (6,000 psi). After cooling to 10°C (50°F), evaporated milk is packaged aseptically in appropriate containers.

Dry Milk Products

Table 1.7 gives the typical composition of dry milk products.

Nonfat dry milk (NFDM) is the product resulting from the removal of fat and water from milk. It contains the lactose, milk proteins, and milk minerals in the same relative proportions as in the fresh milk from which it was made. It contains no more than 5% moisture by weight. The fat content does not exceed 1.5% by weight unless otherwise indicated. NFDM is used in dairy products, bakery goods, dry mixes, chemicals, and meat processing, and in homes for cooking.

NFDM is manufactured by spray drying condensed skim milk. Spray drying involves atomizing concentrated milk into a hot air stream 180°C to 200°C (356°F to 392°F). The atomizer may be a pressure nozzle or a

<table>
<thead>
<tr>
<th>Products</th>
<th>% Water</th>
<th>% Fat</th>
<th>% Protein</th>
<th>% Lactose</th>
<th>% Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dried whole milk</td>
<td>3.0</td>
<td>27.5</td>
<td>26.4</td>
<td>37.2</td>
<td>5.9</td>
</tr>
<tr>
<td>Nonfat dry milk</td>
<td>3.2</td>
<td>0.8</td>
<td>36.0</td>
<td>52.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Dried buttermilk</td>
<td>3.0</td>
<td>5.3</td>
<td>32.4</td>
<td>51.3</td>
<td>8.0</td>
</tr>
<tr>
<td>Spray-dried cream (from 20% cream)</td>
<td>0.6</td>
<td>71.1</td>
<td>11.1</td>
<td>14.7</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Adapted from Chandan (1997), Chandan and O’Rell (2006a)
centrifugal disc. By controlling the size of the droplets, the air temperature, and the airflow, it is possible to evaporate almost all the moisture while exposing the solids to relatively low temperatures. Spray drying yields concentrated and dry milk ingredients with excellent solubility, flavor, and color.

The spray drying process is typically a two-stage process that involves the spray dryer at the first stage with a static fluid bed integrated in the base of the drying chamber. The second stage is an external vibrating fluid bed. The product is moved through the two-stage process quickly to prevent overheating of the powder. The powder leaves the dryer and enters a system of cyclones that simultaneously cools it.

Roller drying is another process but is no longer widely used in the manufacture of most dry milk products. This process involves direct contact of a layer of concentrated milk with the hot surface of rotating rollers. It causes adverse effects of excessive heat on milk components. In this process, heat often causes irreversible changes such as lactose caramelization, Maillard reaction, and protein denaturation. Roller drying typically results in more scorched powder particles and poorer powder solubility than spray drying. However, roller dried milk absorbs more moisture than spray dried powder and is preferred in some food applications such as bakery products.

Instant NFDM is a processed NFDM to improve its dispersion properties. It reconstitutes readily in cold water. The instantizing process involves agglomeration, a process of increasing the amount of air incorporated between powder particles. In one process, a small amount of moisture is incorporated in dry milk particles suspended in air, forming porous aggregates, followed by re-drying and grinding the agglomerated particles. The process results in dry milk with improved reconstitution properties. During reconstitution, the air is replaced by water and incorporated air enables a larger amount of water to come into contact immediately with the powder particles.

Dry whole milk is the product resulting from the removal of water from milk, and it contains not less than 26% nor more than 40% milk fat and not more than 5% moisture (as determined by weight of moisture on a milk solids-not-fat basis). It is manufactured by spray drying whole milk with an added wetting agent, soy lecithin. Reconstituted extra grade whole milk powder possesses a sweet, pleasant flavor. It may have a slight degree of feed flavor, a definite degree of cooked flavor, and no off-flavors. The product should be free of graininess on reconstitution and exhibit no burnt particles. Dry whole milk is used primarily in confectionary, dairy and bakery products.

Dry buttermilk results from the removal of water from liquid buttermilk derived from the churning of butter. It should not be confused with the cultured product known as cultured buttermilk. It contains not less than 4.5% milk fat and not more than 5% moisture. The protein content of dry buttermilk is not less than 30%. Dry buttermilk is used in dairy foods such as ice cream and in other foods such as bakery items, dry mixes, and confectionary.

Dry buttermilk contains higher milk fat than NFDM. It contains a significant level of phospholipids, which act as emulsifying agents. The shelf life due to phospholipids is considerably reduced because they are prone to degradation, causing fishy odors and flavor defects.

Dry buttermilk product is another form of dry buttermilk. This designation indicates that it does not meet the specification of 30% minimum protein content. This product specifies protein content on the label. Except for protein content, dry buttermilk product meets all other standards of dry buttermilk.

Dry buttermilk product results from the removal of water from liquid buttermilk derived from the churning of butter. It does contain not less than 4.5% milk fat and not
more than 5% moisture. Dry buttermilk product contains less than 30% protein; its label should specify the minimum protein content.

**Cultured/Fermented Dairy Products**

Fermentation not only conserves vital nutrients of milk but also modifies certain milk constituents to enhance their functional and nutritional status. Culturing generates live and active cultures in significant numbers to provide distinct health benefits beyond conventional nutrition to the consumer. For more information on cultured milks and yogurt, see the publications of Vedamuthu (2006) and Vasiljevic and Shah (2008). Chapter 13 of this book deals with this subject. Chapter 14 of this book contains information on functional bio-ingredients derived from dairy fermentations. Figure 1.6 shows an outline for the manufacture of cultured/fermented milks including yogurt, cultured buttermilk, sour cream, cream cheese, and cottage cheese.

**Yogurt**

Yogurt is a semisolid fermented product made from a heat-treated and standardized milk mix by the activity of a symbiotic blend of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*. Prebiotic and probiotic cultures currently are also used

---

**Figure 1.6.** Processes for cultured dairy products.
Dairy Ingredients for Food Processing: An Overview

products are designed to be consumed as a spread, as slices in sandwiches, and dips or toppings on vegetables and grain snacks. For a more detailed discussion on cheese, see other publications (Chandan, 2003; Chandan, 2007c; Singh and Cadwallader, 2008). Chapters 10 and 11 of this book discuss natural and process cheese products in detail.

### Table 1.8. Typical composition of some cheeses used as ingredients.

<table>
<thead>
<tr>
<th>Product</th>
<th>% Water</th>
<th>% Fat</th>
<th>% Protein</th>
<th>% Lactose</th>
<th>% Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cottage cheese curd</td>
<td>79.8</td>
<td>0.4</td>
<td>17.3</td>
<td>1.8</td>
<td>0.7</td>
</tr>
<tr>
<td>Cottage cheese, creamed</td>
<td>79.0</td>
<td>4.4</td>
<td>12.5</td>
<td>2.7</td>
<td>1.4</td>
</tr>
<tr>
<td>Cream cheese</td>
<td>53.7</td>
<td>34.9</td>
<td>7.5</td>
<td>2.7</td>
<td>1.2</td>
</tr>
<tr>
<td>Neufchatel</td>
<td>62.2</td>
<td>23.4</td>
<td>10.0</td>
<td>2.9</td>
<td>1.5</td>
</tr>
<tr>
<td>Ricotta</td>
<td>71.7</td>
<td>13.0</td>
<td>11.3</td>
<td>3.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Cheddar</td>
<td>36.8</td>
<td>32.0</td>
<td>26.0</td>
<td>1.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Mozzarella</td>
<td>54.1</td>
<td>21.6</td>
<td>19.4</td>
<td>2.2</td>
<td>2.6</td>
</tr>
</tbody>
</table>

Adapted from Chandan (1997)

in the manufacture of fermented milks and yogurt products to enhance the functional or wellness attributes. A detailed discussion on types of yogurt and their manufacture is available in Chandan and O’Rell (2006a and b). Plain yogurt is a raw material for frozen yogurt, certain margarine products, and salad dressings.

### Cultured Buttermilk

Cultured buttermilk is obtained from pasteurized skim or part skim milk cultured with lactococci and aroma-producing bacteria, leuconostocs (White, 2006). The product is bottled in paper/plastic containers. Cultured buttermilk creates desirable characteristics of texture to bakery items such as pancakes.

### Sour/Cultured Cream

Sour/cultured cream is manufactured by culturing pasteurized cream with lactococci and aroma-producing bacteria, leuconostocs, and has a butter-like aroma and flavor (Born, 2006). Crème fraîche resembles sour cream, except it contains up to 50% fat as compared to 18% fat in sour cream and has a higher pH of 6.2 to 6.3. Cultured cream is used in making dips and is an integral constituent of Mexican cuisine.

### Cheese

Cheese and cheese products are consumed as such or are used as ingredients in entrees, side dishes, and ready-to-eat snacks. These products are designed to be consumed as a spread, as slices in sandwiches, and dips or toppings on vegetables and grain snacks. For a more detailed discussion on cheese, see other publications (Chandan, 2003; Chandan, 2007c; Singh and Cadwallader, 2008). Chapters 10 and 11 of this book discuss natural and process cheese products in detail.

### Unripened Natural Cheese

#### Cottage Cheese

Cottage cheese belongs to the class of natural, unripened soft cheeses (Chandan, 2003). It is a relatively low-fat product with high protein content and is part of low-calorie diets, including salads. It is used as a filling in the preparation of the breakfast food blintze. Good-quality cottage cheese has a clean, creamy, cultured milk flavor, a natural creamy color, and a meaty, soft texture. It comes in small or large curd sizes. The curd is coated with a cream dressing.

#### Cream Cheese

Cream cheese contains at least 33% fat and not more than 55% moisture. It is a soft, unripened lactic-acid-coagulated cheese. It is made by culturing cream by a process similar to that of cottage cheese (Chandan, 2003). It has a mild, acid, and creamy flavor. It is a major ingredient of cheese cakes.
Ricotta Cheese

Ricotta cheese is made from whey or a blend of whey and milk by direct acidification with a food-grade acid. Ricotta made from 95% sweet whey and 5% milk contains 68% to 73% moisture, 16% protein, 4% to 10% fat, and 4% lactose (Chandan, 2003). Ricotta has a bland to a slightly cooked flavor. Its texture is soft and creamy. It is used in Italian cuisine, particularly in lasagna and ravioli.

Ripened Natural Cheese

Ripened natural cheese is made directly from milk and some cases cheese whey. It is made by coagulating or curdling milk, stirring and heating the curd, draining off the whey, and collecting or pressing the curd. Desirable flavors and textures are obtained in many cheeses by a curing process at a specified temperature, humidity, and time period. Many cheese varieties are used as ingredients in popular main-meal items. Functional cheese derivatives have been developed for use in specialty food products. For example, quick-melting cheese slices for cheeseburgers, cheese sauces for Mexican dishes, and high-melt cheese products for filling meat products are commercially manufactured to meet demands of fast food and other food service businesses.

Production of cheese ingredients is based on natural cheese as an intermediate ingredient. The principles of production of cheddar and other cheese varieties are discussed elsewhere (Singh and Cadwallader, 2008). Nevertheless, a summary of the procedure for cheese manufacture is given below.

Raw milk is standardized to a casein:fat ratio of 0.7, pasteurized, and transferred to a cheese vat at 31.1°C (88°F). Cheese color may be added as an optional ingredient. A cheese culture at 1% level is then mixed with milk. As the culture grows, acidity starts to build in the milk. When acidity rises by 0.05% to 0.1%, rennet (a coagulating enzyme) is added at the rate of 3 oz/1,000 lbs milk.

The milk sets to a firm gel. After about 20 minutes, the gel is cut into one-quarter-inch or three-eighths-inch cubes by special wire-mesh knives. At this point, whey acidity should be 0.1% to 0.12% and the curd cubes and whey start to separate out. The next step is cooking, which involves raising the temperature of the vat contents from 31.1°C to 36.7°C to 38.9°C (88°F to 98°F to 102°F) until an acidity of 0.17% to 0.20% is obtained. Whey, the liquid portion, is drained, and the solid portion (curd) is allowed to build higher acidity at 37.8°C to 38.9°C (100°F to 102°F). Curd starts to knit or mat as a slab and the process of cheddaring is terminated at an acidity of 0.6%. The matted slab is then milled to form small size cheese curd, salted, and pressed into blocks or barrels. The blocks are then packaged and ripened at 7.2°C (45°F) for a period varying from 3 months to 1 year.

For retail sale, ripened cheese is packaged after cutting the blocks into 8-oz to 2-lb portions. Special wrapping materials are available to exclude entry of oxygen into the package and prevent loss of moisture. Plastic film pouches are formed to insert the cheese cuts, followed by evacuation of air and heat sealing. Shrinking of the wraps takes place by passing cheese packages through hot air/steam chambers to provide a skin-tight attractive appearance.

The whey fraction is separated to remove cream, condensed, and spray dried to produce sweet whey powder, which is widely used in several bakery items. Several whey fractions are clinically proven to possess bioactive properties and are now key constituents of functional or wellness foods.

Process Cheese and Products

Process Cheese

Natural cheese constitutes a main ingredient for the manufacture of process cheese and its products. Process cheese delivers fairly uniform flavor and texture as compared to
natural cheese. Its melting characteristics can be manipulated by use of specific melting (or emulsifying) salts. Normal variations in flavor of natural cheese are minimized by blending of mild and strong flavors (and ages) of natural cheese. Selected cheeses are macerated and transferred to a cooking vat. Emulsifying salts are used to prevent separation of fat during heat processing. The salts commonly used (up to 4% level) are citrates and phosphates. The salts result in desirable body of the product. If desired, other ingredients such as sodium chloride, preservatives, cream, dry milk, and whey may be added.

The mixture is heated to 79.4°C to 82.2°C (175°F to 180°F) for one to five minutes with vigorous agitation. Scraped surface equipment is necessary to facilitate heat transfer. The mixture turns fluid and a homogeneous mass is obtained. The product is ready for packaging into forms and cooled to obtain process cheese loaves. Process cheese contains higher moisture than natural cheese. To obtain cheese slices, molten cheese is subjected to casting on a roller drum, followed by cutting into ribbons and slices, and packaging.

**Pasteurized Process Cheese Food**

Pasteurized process cheese food is similar to pasteurized process cheese, except it must contain moisture not exceeding 44%, and fat content is not less than 23%. It contains optional dairy ingredients: cream, milk, skim milk, buttermilk, cheese whey solids, anhydrous milk fat, and skim milk cheese for manufacturing. The pH is adjusted to not below 5.0 with vinegar, lactic acid, citric acid, phosphoric acid, or acetic acid. It cannot contain more than 3% emulsifying agents. Sorbic acid (up to 0.2%) is allowed as a preservative. The product is obtained by blending American cheeses of different ages with nonfat dry milk and whey and other permissible ingredients, followed by pasteurization. It melts quickly to give a smooth liquid. Cold product can be sliced easily. Major uses include entrees, au gratin potatoes, sandwiches, and Mexican dishes. It may be flavored with seasonings, smoke, pimento, jalapeno, salami, pepperoni, etc. Moisture content is 44% maximum and fat in dry matter is 41% minimum.

**Pasteurized Process Cheese Spread**

Pasteurized process cheese spread contains even higher moisture and lower fat than process cheese food. It is more spreadable
Cheese powders can be packed in nitrogen atmosphere to give a longer storage life. Hard Italian cheese (namely, parmesan) is dried after grating in tray or belt dryers in which dry, hot air is circulated to reduce moisture to less than 6%. The cheese is ground and packaged after cooling. Cheese powders are popular toppings in Italian cuisine. More details on cheese powders, enzyme-modified cheese, and cheese sauces can be found in Chapter 12.

**Enzyme-modified Cheeses**

Enzyme-modified cheeses (EMC) are cheese flavor concentrates obtained by treating raw cheese curd with specific lipases/pregastric esterases and proteases followed by fermentation with a cheese culture. It takes one to three days to develop a flavor concentration of 10- to 20-fold as compared to ripened cheeses. Cheese paste is then heat treated to stop the biochemical reaction, and cooled. The EMC may be purchased as a paste or it may be blended with whey and dried as a spray-dried powder. EMCs offer significant savings as substitutes for aged cheese in cheese-flavored crackers and fillings for bakery items. It also is an economical ingredient in process cheese manufacture.

**Cheese Sauces**

Cheese sauces are aseptically processed slurries that are canned for convenient use as dips or as sauces on nachos, potatoes, and pasta. Typically, the ingredients used are cheddar cheese, skim milk, whey, buttermilk, vegetable oil, starch, sodium phosphate, salt, caseinate, citrate, color, lactic acid, stabilizers, emulsifiers, and seasonings.

**Whey Products**

Whey, the greenish-yellow liquid produced from the manufacture of cheese, contains about half of the solids of whole milk. Its composition depends largely on the variety
of cheese being made. These solids are valuable additions to the functional properties of various foods, as well as a source of valuable nutrients. The techniques of concentration, drying, and reverse osmosis recover virtually all of the whey solids. Crystallization, ion exchange, and membrane systems such as ultrafiltration and electrodialysis are used for fractionating whey into concentrates of protein, minerals, and lactose. See Kilara (2008) and Chapter 8 of this book for details. Figure 1.7 shows an outline for the manufacture of whey products and milk protein concentrate. The proximate composition of dry whey, whey products, caseinates, and milk protein concentrates is shown in Table 1.9.
Chapter 1

Dried by dehumidified air that moves through the porous bed.

Dry sweet whey is widely used in bakery products, dry mixes, process cheese foods and spreads, frozen desserts, sauces, meat emulsions, confections, soups, gravies, snack foods, and beverages. Dry acid whey has an additional functional attribute of providing acid flavor in certain foods and it imparts desirable textural properties to bakery items.

Fractionated Whey Products

Membrane technology is used for partial concentration (reverse osmosis); fractionation of solutes (lactose, minerals) from macromolecules such as proteins, fat globules, colloidal particles, (ultra-filtration); and demineralization (ion-exchange, electro-dialysis) of whey, its fractions, and milk. These processes produce highly functional ingredients. The membrane processes are pressure-activated processes that separate components on the basis of molecular size and shape. Reverse osmosis is the process in which virtually all species except water are rejected by the membrane. The osmotic pressure of the feed stream in such a system is often quite high. Consequently, to achieve adequate water flux rates through the membrane, such systems often use hydrostatic operating pressures of

**Table 1.9.** Proximate composition of dry whey and other dairy products.

<table>
<thead>
<tr>
<th>Product</th>
<th>% Water</th>
<th>% Fat</th>
<th>% Protein</th>
<th>% Lactose</th>
<th>% Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry sweet whey</td>
<td>4.5</td>
<td>1.1</td>
<td>12.9</td>
<td>73.5</td>
<td>8.0</td>
</tr>
<tr>
<td>Reduced lactose whey</td>
<td>4.0</td>
<td>2.5</td>
<td>22.0</td>
<td>55.0</td>
<td>16.5</td>
</tr>
<tr>
<td>Demineralized whey</td>
<td>4.0</td>
<td>2.2</td>
<td>13.0</td>
<td>76.8</td>
<td>4.0</td>
</tr>
<tr>
<td>Dry acid whey</td>
<td>4.3</td>
<td>1.0</td>
<td>12.3</td>
<td>71.3</td>
<td>11.1</td>
</tr>
<tr>
<td>Whey protein concentrate, 34% protein</td>
<td>3.5</td>
<td>4.0</td>
<td>34.5</td>
<td>51.0</td>
<td>7.0</td>
</tr>
<tr>
<td>Whey protein concentrate, 50% protein</td>
<td>3.5</td>
<td>4.0</td>
<td>50.5</td>
<td>36.0</td>
<td>6.0</td>
</tr>
<tr>
<td>Whey protein concentrate, 80% protein</td>
<td>3.5</td>
<td>6.0</td>
<td>80.5</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Whey protein isolate</td>
<td>3.5</td>
<td>0.5</td>
<td>93.0</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Acid casein</td>
<td>9.0</td>
<td>1.0</td>
<td>88.0</td>
<td>0.1</td>
<td>1.9</td>
</tr>
<tr>
<td>Ren net casei n</td>
<td>11.0</td>
<td>1.0</td>
<td>85.0</td>
<td>0.1</td>
<td>2.9</td>
</tr>
<tr>
<td>Calcium caseinate</td>
<td>3.5</td>
<td>1.0</td>
<td>91.0</td>
<td>0.1</td>
<td>4.4</td>
</tr>
<tr>
<td>Sodium caseinate</td>
<td>3.0</td>
<td>1.5</td>
<td>90.9</td>
<td>0.1</td>
<td>4.5</td>
</tr>
<tr>
<td>Milk protein concentrate</td>
<td>4.0</td>
<td>3.0</td>
<td>65.0</td>
<td>22.0</td>
<td>6.0</td>
</tr>
<tr>
<td>Food grade lactose</td>
<td>0.5</td>
<td>0.1</td>
<td>0.1</td>
<td>99.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Dairy minerals concentrate</td>
<td>10.0</td>
<td>1.0</td>
<td>8.0</td>
<td>1.0</td>
<td>80.0</td>
</tr>
</tbody>
</table>

Adapted from Chandan (1997), Sodini and Tong (2006), Chandan and O’Rell (2006a)
In the ion-exchange process, whey is passed through two containers that are filled with special synthetic resins that have the ability to exchange ions. In the first container, the special synthetic resins exchange hydrogen ions for cations in the whey. Here the positive ions of the salt are captured and acid is formed by the release of hydrogen ions. The whey is then passed over the anion exchanger where hydroxyl ions are exchanged for negative ions of the salt, and water is formed. When the mobile ions of the resins are completely replaced by other ions, the resin must be regenerated for further use.

Electrodialysis, a combination of electrolysis and dialysis, is the separation of electrolytes under the influence of an electric potential through semi-permeable membranes. The driving force is an electric field between the anode (positively charged) and the cathode (negatively charged). Between the anode and the cathode, a number of ion-selective membranes are placed which are permeable only to anions or cations. Every other membrane has a positive charge repelling positive ions and allowing negative ions to pass, and in between there is a negatively charged membrane doing just the opposite.

The permeate is used for manufacture of milk sugar, lactose, by condensing and crystallization. Lactose crystals are harvested and dried in a tumble dryer.

**Reduced Lactose Whey**

Reduced lactose whey is produced from whey by partial crystallizing out lactose and recovery of mother liquor by centrifugation, followed by drying. Lactose content of the dry product is 60% or less.

**Reduced Minerals Whey**

Reduced minerals whey is produced from whey by selective removal of a portion of minerals. Ash content of the dry product is 7% or less. Demineralization processes have helped in the development in an array of whey products. Excessive mineral content makes dry whey distasteful, and can have an adverse affect on the physical properties of some foods. The two most widely used demineralization processes for whey are ion exchange and electrodialysis.

In principle, whey is pumped through every second space between two membranes, and a solution of sodium chloride (cleaning solution) is pumped through the compartments between the whey streams. The ions move from the whey stream into the cleaning solution where they are retained, because they cannot move any farther. The cleaning solution contains minerals, acid, some lactose, and small nitrogenous molecules. The membranes are cleaned chemically. Protein molecules remain in the fluid while the minerals are removed. The process results in a protein concentrate.

**Lactose**

Lactose is crystallized from condensed whey or from permeate (50% to 60% solids)
obtained by ultrafiltration fractionation of milk or whey. The supersaturated solution is cooled under specific conditions to crystallize lactose. Lactose crystals are harvested and washed to remove the mother liquor and dried. Crude lactose obtained this way contains approximately 98% lactose. Edible and USP grades are produced from crude lactose by protein precipitation, de-colorization with activated carbon, and subsequent demineralization. Lactose is further refined by re-crystallization, followed by spray drying.

**Whey Protein Concentrates and Isolates**

Whey protein concentrates are products derived from whey by removal of minerals and lactose. The process of protein concentration uses ultrafiltration, electrodialysis, and ion exchange technologies. On dry basis, the protein concentrate contains a minimum of 25% protein. Whey protein isolate contains at least 90% protein.

Whey protein concentrate of 34% protein is commonly used in yogurt, bakery mixes, dietetic foods, infant foods, and confections. Its water binding, fat-like mouth feel, and gelation properties are particularly useful in these products. Whey protein concentrate of 50% or 80% protein offers distinct functional attributes. It is especially suited for use in nutritional drinks, bars, soups, bakery items, meat products, dietary foods, and protein-fortified beverages. It gives clear suspensions over a wide pH range and has a bland flavor. Some applications require undenatured ingredients to maximize water-binding capacity during food processing. It is also available in a gel-forming version. Fractionated and hydrolyzed whey protein products are now marketed as health-promoting functional foods.

**Casein and Caseinates**

Casein is obtained from pasteurized skim milk by precipitation with an acid, followed by drying. This gives acid casein. Acid casein is produced by precipitation of skim milk with hydrochloric acid, sulfuric acid, acetic acid, or lactic acid at pH 4.6. Casein derived from the action of rennet (chymosin) is called rennet casein. Micellar casein is also commercially available. They all have distinctive functional characteristics.

Caseinates are derived from casein by treatment with a suitable alkali. Casein is basically insoluble in water, whereas caseinates are easily dispersible. Acid casein is neutralized to pH 6.7 with sodium hydroxide for the production of sodium caseinate. Similarly, potassium hydroxide and calcium hydroxide yield potassium and calcium caseinates, respectively. This subject is discussed in Chapter 7.

**Milk Protein Concentrate**

Milk protein concentrate is obtained by ultrafiltration of skim milk and subsequent spray drying. The protein content varies according to the application in dairy products and functional foods. An outline for the manufacture of milk protein concentrate is shown in Figure 1.7.

The applications of dairy ingredients in dairy foods are discussed in Chapter 17. Chapter 18 gives the applications in bakery, meat products, dressings, sauces, and soups. Chocolates and confections are given in Chapter 19. Infant formulas, nutritional drinks, and bars are discussed in Chapter 20.

**Trends in Availability and Use of Major Dairy Ingredients**

Selection of a dairy ingredient is largely based on the desired contribution of certain milk constituents such as milk fat and solids-not-fat (proteins, lactose, and minerals) in a given food. Cost and availability also contribute significantly to the use of a particular ingredient. It is helpful to understand recent trends in production of major dairy products
Table 1.10. Production of major dairy ingredients in 2008.

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Production, 1,000 pounds</th>
<th>% Change from 2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>189,992,000</td>
<td>2.3</td>
</tr>
<tr>
<td>Butter</td>
<td>1,644,078</td>
<td>7.3</td>
</tr>
<tr>
<td>Total cheese</td>
<td>9,934,530</td>
<td>1.6</td>
</tr>
<tr>
<td>Canned evaporated and condensed whole milk</td>
<td>587,745</td>
<td>18.2</td>
</tr>
<tr>
<td>Canned evaporated skim milk</td>
<td>18,313</td>
<td>−1.2</td>
</tr>
<tr>
<td>Bulk sweetened condensed whole milk</td>
<td>83,100</td>
<td>5.3</td>
</tr>
<tr>
<td>Bulk unsweetened condensed whole milk</td>
<td>134,824</td>
<td>27.2</td>
</tr>
<tr>
<td>Bulk sweetened condensed skim milk</td>
<td>29,106</td>
<td>NA</td>
</tr>
<tr>
<td>Bulk unsweetened condensed skim milk</td>
<td>1,509,246</td>
<td>−7.9</td>
</tr>
<tr>
<td>Condensed/evaporated buttermilk</td>
<td>64,115</td>
<td>15.0</td>
</tr>
<tr>
<td>Dry whole milk</td>
<td>50,137</td>
<td>57.9</td>
</tr>
<tr>
<td>Nonfat dry milk, human grade</td>
<td>1,519,173</td>
<td>17.0</td>
</tr>
<tr>
<td>Dry skim milk, animal grade</td>
<td>8,283</td>
<td>70.3</td>
</tr>
<tr>
<td>Dry skim milk protein standardized and blends</td>
<td>373,830</td>
<td>86.3</td>
</tr>
<tr>
<td>Dry buttermilk</td>
<td>72,494</td>
<td>−10.9</td>
</tr>
<tr>
<td>Sour cream</td>
<td>1,127,079</td>
<td>−0.7</td>
</tr>
<tr>
<td>Cream and Neufchatel cheese</td>
<td>763,692</td>
<td>−1.2</td>
</tr>
<tr>
<td>Condensed whey, sweet, human grade</td>
<td>103,936</td>
<td>NA</td>
</tr>
<tr>
<td>Dry whey, total</td>
<td>1,107,539</td>
<td>−2.3</td>
</tr>
<tr>
<td>Reduced lactose and mineral dry whey, human food grade</td>
<td>36,962</td>
<td>NA</td>
</tr>
<tr>
<td>Reduced lactose and mineral dry whey, animal grade</td>
<td>51,788</td>
<td>NA</td>
</tr>
<tr>
<td>Whey protein concentrate, 25.0% to 49.9% protein</td>
<td>286,214</td>
<td>NA</td>
</tr>
<tr>
<td>Whey protein concentrate, 50.0% to 89.9% protein</td>
<td>137,433</td>
<td>NA</td>
</tr>
<tr>
<td>Whey protein isolate, 90% or higher protein</td>
<td>43,204</td>
<td>NA</td>
</tr>
<tr>
<td>Lactose, human and animal grades</td>
<td>755,295</td>
<td>−1.4</td>
</tr>
</tbody>
</table>

NA, not available  
Source: USDA (2009)

(Table 1.10) impacting their availability and cost.

In 2008, 14.7% of the U.S. milk supply was used as fluid milk and 7.3% for fluid cream products. The remainder was used in production of cheese (40.6%), butter (19%), frozen desserts (7.9%), dry milk products (0.5%), and cultured dairy products (4.9%). About 0.6% of milk production was used on the farms, and other uses accounted for 4.6% of milk supply (IDFA, 2009).

In 2002, uses of nonfat dry milk (in million pounds) were as follows:

- Dairy: 617.1
- Bakery: 59.6
- Confectionery: 58.2
- Pharmaceutical, special dietary, nutraceuticals: 58.2
- Prepared dry mixes: 52.5
- Beverages: 24.5
- Infant formula: 19.3
- Animal feed: 11.6
- Meat processing: 8.3
- Institutional use: 8.3
- Soups: 3.4
- Margarine: 1.2
- Packaged for retail: 1.2
- Other uses: 4.2

Dry whole milk was used (in million pounds) in confectionary (39.1), prepared dry mixes (3.6), dairy (3), packaged for retail use (2.1), bakery (1.1), animal feed (0.2), and institutional use (0.1). Dry buttermilk (a byproduct of butter manufacture) was used (in million pounds) as follows: 15.7 in prepared dry mixes, 15.1 in bakery, 9 in dairy, 3.6 in confectionery, 0.7 in animal feed, and 0.3 in other uses.

The cheese industry has been a growth industry for many years. A record high production 9.9 billion pounds was registered in 2008. Estimated total wholesale value of
cheese and cheese products in 2007 was $33 billion.

Most of the growth in natural cheese category can be attributed to growth in mozzarella and pizza cheese. The U.S. production of Italian style cheese increased to 4,158 million pounds in 2008. Mozzarella cheese constitutes 78% of Italian cheese varieties. For comparison, production of American cheese varieties was a little lower than that of Italian cheeses and amounted to 4,071 million pounds.

The per capita consumption of natural and processed cheese products is given in Table 1.11.

The 2008 cheese consumption (excluding cottage cheese) reached a record level of 32.4 pounds per capita. Although there are more than 300 varieties of cheese available in the U.S., the most popular cheeses include Mozzarella with per capita consumption of 10.65 pounds, followed by cheddar at 9.96 pounds per capita. Consumption of all Italian cheeses and all natural cheeses continues to grow. Trends in total processed cheese consumption show a slight decrease.

Note: Some of the information in this chapter has been derived from Chapter 1 of Dairy Processing and Quality Assurance: An Overview, published in Dairy Processing and Quality Assurance (Wiley-Blackwell, 2008).

References


