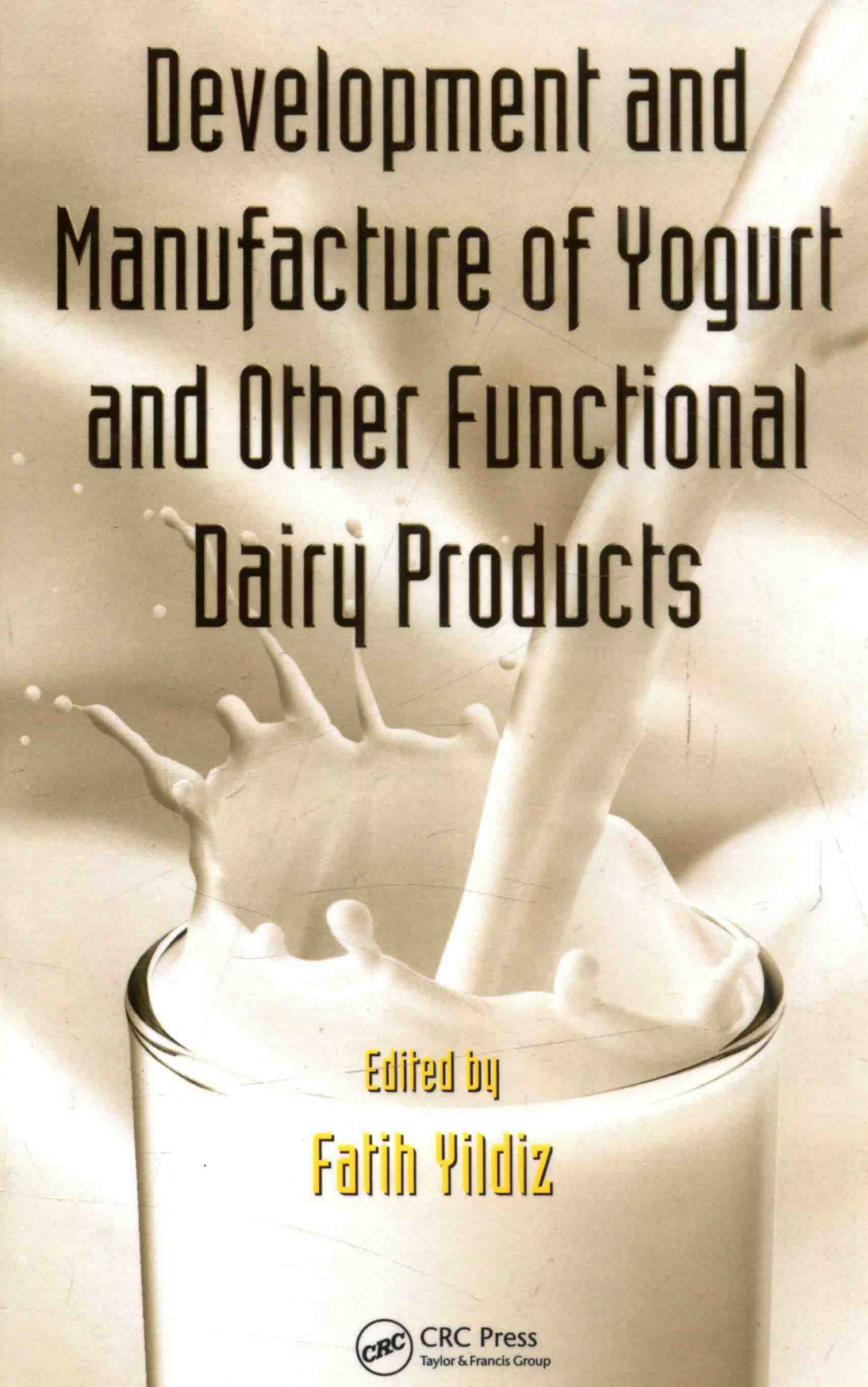
Development and Manufacture of Yogurt and Other Functional Dairy Products



Edited by

Fatih Yildiz

CRC Press
Taylor & Francis Group

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CRC Press
Taylor & Francis Group
Boca Raton London New York

CRC Press is an imprint of the
Taylor & Francis Group, an **informa** business

CRC Press
Taylor & Francis Group
6000 Broken Sound Parkway NW, Suite 300
Boca Raton, FL 33487-2742

Printed in the United States of America on acid-free paper
10 9 8 7 6 5 4 3 2 1

International Standard Book Number: 978-1-4200-8207-4 (Hardback)

Library of Congress Cataloging-in-Publication Data

Development and manufacture of yogurt and other functional dairy products / editor, Fatih Yildiz.
p. ; cm.
Includes bibliographical references and index.
ISBN 978-1-4200-8207-4 (hardcover : alk. paper)
1. Yogurt--Microbiology. 2. Dairy microbiology. 3. Fermentation. I. Yildiz, Fatih.
[DNLM: 1. Yogurt--microbiology. 2. Dairy Products--microbiology. 3. Fermentation.
4. Foods, Specialized. 5. Nutritional Physiological Phenomena. QW 85 D489 2010]

QR121.D48 2010
641.3'7--dc22 2009031466

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Preface

Yogurt and related yogurt-like dairy beverages (ayran, kefir, and koumiss) are unique in taste and nutrition and are probably the first functional foods to be researched by the scientific community. They have a very long history of being in the homemade foods category and have many nutritional attributes. Yogurt holds the secrets behind good health and nutrition, which have not been completely understood even after 5000 years of consuming it. It is a perfect alternative to the junk and snack foods and beverages consumed today.

The Russian bacteriologist Ilya Metchnikoff was the first scientist to perform research on yogurt, yogurt beverages, and human longevity, which he did when he was the director of the Louis Pasteur Institute in Paris, France, from 1889 until his death in 1916. Mechnikoff received the Nobel Prize in 1908 for his work on phagocytosis in relation to wounds, diseases, immunity, and normal healthy life.

Yogurt products include plain yogurt, fruit yogurts, pasteurized and sterilized yogurts, dried yogurts, yogurt mixes and instant yogurt, acidophilus yogurt, liquid yogurt, frozen yogurts, and many others. Yogurt can be consumed as a complete lunch, breakfast, dinner, between-meal snack, as a beverage, or with many vegetable dishes, at any time of the day. Yogurt-related beverages include cacık and several other probiotic beverages.

During the past two decades, there has been renewed interest in the study and understanding of the nutritional and therapeutic aspects of dairy products; this book will enlarge our knowledge of these less-known aspects of fermented dairy products.

Beneficial effects attributed to yogurt and fermented dairy beverages include the anticarcinogenic and immunological properties of lactic acid bacteria (LAB), bone and gastrointestinal health, and many others.

The health benefits of cultured milk products with viable and nonviable bacteria are now well recognized, but there is still much confusion that needs to be solved.

This book will definitely be of great help to all those involved in the manufacture or study of milk and dairy products.

Fatih Yıldız

Acknowledgments

I would like to acknowledge and extend my heartfelt thanks to the following people who have made the completion of this book possible:

My friends and colleagues:

Prof. Dr. Celalettin Koçak of Ankara University
Prof. Dr. Barbaros Özer of Abant Izzet Baysal University
Prof. Dr. Candan Gürakan of Middle East Technical University
Prof. Dr. Theodoros H. Varzakas of the Technological Educational Institute of Kalamata

Thanks are due to the contributors of this book, that is, 20 scientists from 12 different universities, whose names and affiliations are given in this book.

Special thanks to Edmund Zottola, Professor Emeritus at the University of Minnesota, who helped me to understand the dairy industry.

Special thanks to my family and friends for their patience during the preparation of this book.

And finally, many thanks to Stephen Zollo, Kari Budyk and Rachael Panthier of Taylor & Francis for producing this book.

Editor

Fatih Yıldız received his BS degree from Atatürk University, Erzurum, Turkey, as an agricultural engineer. He also received a BS degree in biochemistry from the University of Wisconsin. Later he received his MS and PhD degrees in food biochemistry from the University of Maryland. He worked as a faculty member at the University of Maryland for five years. In 1980, Dr. Yıldız joined the Middle East Technical University (METU) Department of Chemical Engineering and was actively involved in the establishment of the food engineering, biochemistry, and biotechnology departments at that university. Dr. Yıldız also worked as a professor at the University of Minnesota, Department of Food Science and Nutrition. He has done research at the French National Institute for Agricultural Research (INRA), France, as a visiting professor in 1997. Additionally he has done research projects with FAO, UNIDO, UNICEF, and NATO as a project director.

Currently he is teaching and doing research at the Middle East Technical University, Food Engineering and Biotechnology Departments, Ankara, Turkey.

Dr. Yıldız has published more than 130 research and review papers in international and national journals as the major author. His papers have been cited by *Science Citation Index* many times. He has coauthored a book entitled *Minimally Processed and Refrigerated Fruits and Vegetables*, published by Chapman & Hall in 1994, which was then a new concept in the food industry.

His current research interests include health nutrition, and the safety attributes of the Mediterranean Diet. He is the editor of the first book on phytoestrogens, entitled *Phytoestrogens in Functional Foods* published by CRC Press.

Professor Yıldız is listed in *Who's Who in Turkey and Europe* and serves on numerous advisory committees of the Ministry of Health and Agriculture in Turkey. He is a member of 10 scientific and academic organizations in the United States, France, and Turkey.

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1 Overview of Yogurt and Other Fermented Dairy Products

Fatih Yıldız

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1.1 HISTORICAL PERSPECTIVES

Humans have evolved in close contact with Nature, and the first food that Nature provided for man was milk. Throughout most of the evolution of the human history, from 200,000 years BP (before present) up to 15,000 BP, the sole source of milk was from mother to newborn baby. In early times, when Nature failed to give milk to the child with a lactating mother, the baby either suckled another mother or died [1].

Then, as man domesticated animals, at first goat and sheep (about 13,000 BP) and later cow (9000 BP), milk from other mammals became available to provide essential nutrients. Since that time (13,000 BP), young and old, men and women, and all humans have been using milk as food [2].

The importance of milk to humans as food:

a. Domestication of animals has made it possible for humanity to have a secure source of milk all year round (Figure 1.1) [2]
b. Milk has contributed for the nutrition of humans of all ages, decreasing infant mortality and increasing well-being of mammalian infants [1]
c. Fermented milk consumption has increased adult human height, bone density, adult body mass, longevity, and adult brain volume (cm^3) over the last 13,000 years [3]

There is evidence of cultured milk products being produced as food for at least 8000 years. The earliest yogurts were probably spontaneously fermented by wild bacteria living on the goat skin bags carried by nomadic people. Today, many different countries claim yogurt as their own invention, yet there is no clear evidence as to where it was first discovered, and it may have been independently discovered several times [4].

The use of yogurt by mediaeval Turks is recorded in the books *Diwan Lughat al-Turk* by Mahmud Kashgari [5] and *Kutadgu Bilig* by Yusuf Has Hajib [6] written in the eleventh (1070 AD) century. In both texts the word "yogurt" is mentioned in different sections and its use by nomadic Turks is described. These two books are the earliest recorded information about yogurt. The first account of a European encounter with yogurt occurs in French clinical history: Francis I suffered from a severe diarrhea that no French doctor could cure. His ally Suleiman the Magnificent, an Ottoman sultan, sent a doctor, who allegedly cured the patient with yogurt [7].

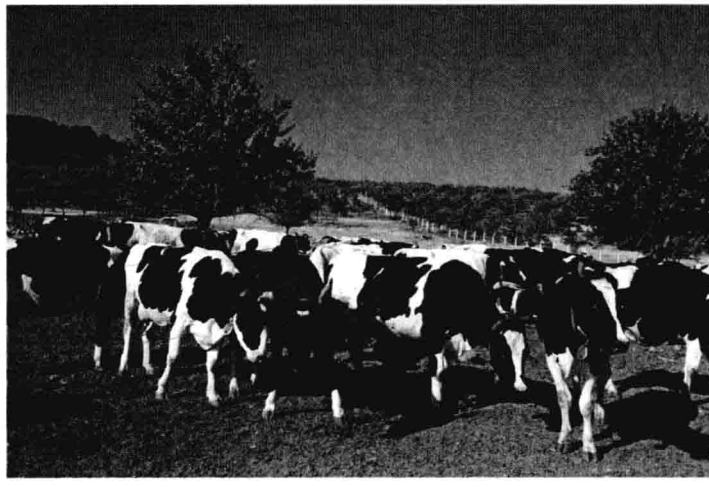

FIGURE 1.1 **(See color insert following page 212.)** Holstein cows before milking.

In 1908, Elie Metchnikov, Nobel Laureate for the discovery of phagocytic (cell-eating) cells, proposed in his book "The Prolongation of Life" [8] that the secret to longevity lies in maintaining healthy colon bacteria. He even named the bacteria responsible, *Lactobacillus bulgaricus* (LB), after the Bulgarians, whose health and longevity he attributed to the large quantities of yogurt they typically ate. While his conclusions were met with skepticism for many years, healthy gut bacteria are now decidedly back as probiotics.

1.2 YOGURT ETYMOLOGY AND SPELLING

The word is derived from the Turkish word *yoğurt* [9] and is related to *yoğurmak* "to knead" and *yoğun* "dense" or "thick" [10]. The letter ğ was traditionally rendered as "gh" in transliterations of Turkish, which used to be written in a variant of the Arabic alphabet until the introduction of the Latin alphabet in 1928. In older Turkish the letter denoted a voiced velar fricative |ɣ|, but this sound is elided between back vowels in modern Turkish, in which the word is pronounced (yoğurt, jogurt). Some eastern dialects retain the consonant in this position, and Turks in the Balkans pronounce the word with a hard /g/ [11].

1.3 YOGURT

Yogurt is made by introducing specific bacteria strains into milk, which is subsequently fermented under controlled temperatures (42–43°C) and environmental conditions (in fermentation tank), especially in industrial production (Figure 1.2). The bacteria ingest natural milk sugars and release lactic acid as a waste product. The increased acidity causes milk proteins to coagulate into a solid mass (curd) in a process called denaturation [12]. The increased acidity (pH = 4–5) also prevents the proliferation of potentially pathogenic bacteria. In most countries, to be named

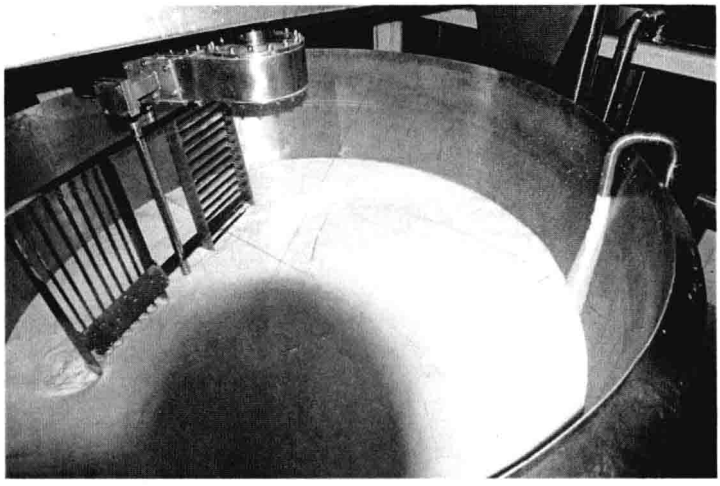

FIGURE 1.2 **(See color insert following page 212.)** Yogurt culture addition in a tank.

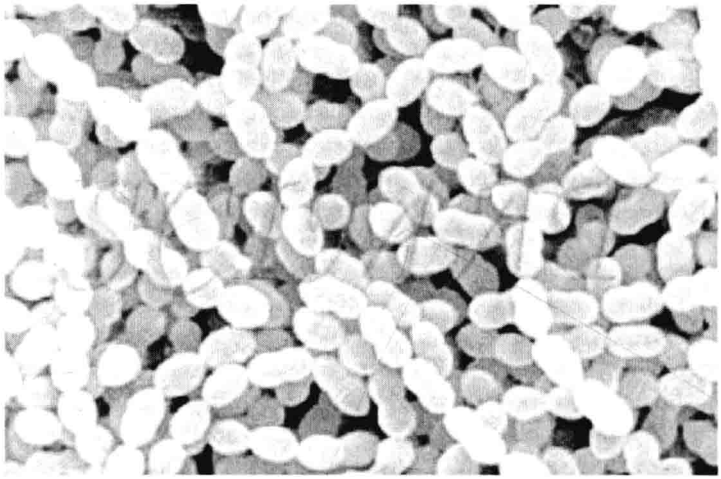

FIGURE 1.3 (See color insert following page 212.) *Streptococcus salivarius* subsp. *thermophilus.*

yogurt, the product must be made with the bacterial species *Streptococcus salivarius* subsp. *thermophilus* (ST) and *Lactobacillus delbrueckii* subsp. *bulgaricus* (Figures 1.3 through 1.5). Often these two are cocultured with other lactic acid bacteria for taste or health effects (see Chapter 6). These include *Lactobacillus acidophilus* (LA), *Lactobacillus casei*, and *Bifidobacterium* species. In the United States and in the European Union countries, a product may be called yogurt only if live bacteria are present in the final product. In the United States, nonpasteurized yogurt can be marketed as "live" or containing "live active culture." A small amount of live yogurt can be used to inoculate a new batch of yogurt, as the bacteria reproduce and multiply

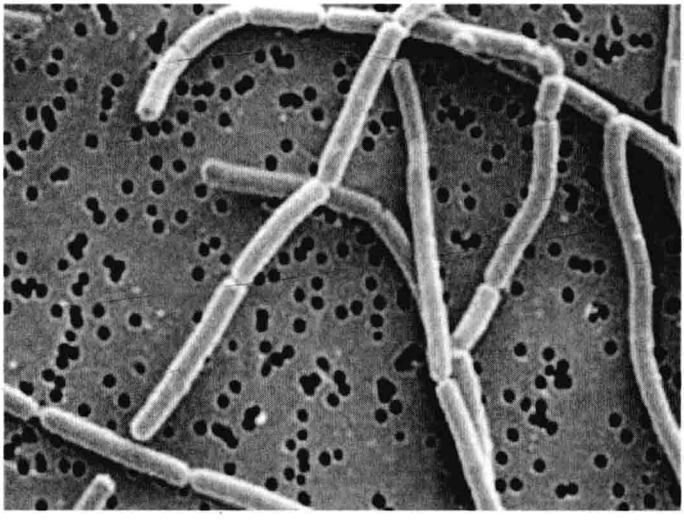

FIGURE 1.4 (See color insert following page 212.) *Lactobacillus delbrueckii* subsp. *bulgaricus.*

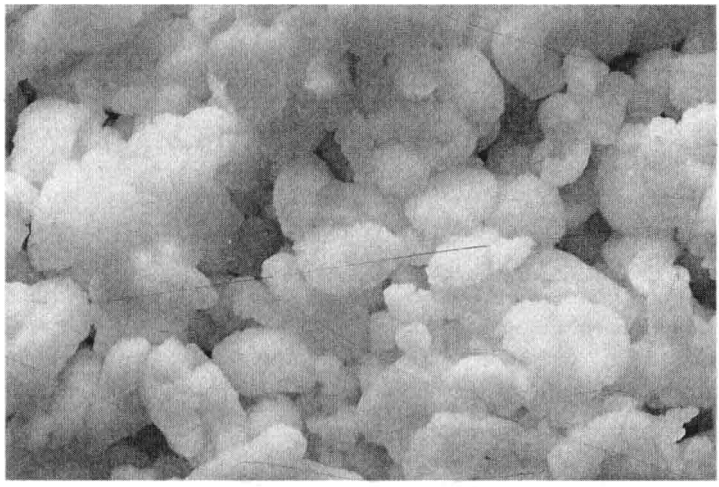

FIGURE 1.5 (See color insert following page 212.) *Lactobacillus delbrueckii* subsp. *bulgaricus* in coagulated milk.

during fermentation [13]. Pasteurized products, which have no living bacteria, may be called fermented milk product. When yogurt is pasteurized, even though its main aim is to kill harmful bacteria, it kills large amounts of essential bacteria too, such as *Acidophilus*, *Bifidus*, and *Lactobacillus rhamnosus*. Yogurt is a semisolid fermented milk product. Its popularity has grown and is now consumed in most parts of the world. Although the consistency, flavor, and aroma may vary from one region to another, the basic ingredients and manufacturing are essentially consistent [14]. Important parameters in yogurt manufacturing include ingredients, starter culture, and manufacturing methods (see Chapters 2 and 3).

1.3.1 Yogurt Types

a. *Set yogurt*: A solid set where the yogurt forms in a consumer container and is not disturbed (Figure 1.6).
b. *Stirred yogurt*: Yogurt is first made in a large container and then spooned or otherwise dispensed into secondary serving containers. The consistency of the "set" is broken and the texture is less firm than set yogurt. This is the most popular form of commercial yogurt.
c. *Drinking sweet yogurt*: Stirred yogurt to which additional milk and flavors are mixed in. Fruit or fruit syrups are added to taste. Milk is added and mixed to achieve the desired thickness. The shelf life of this product is 4–10 days, since the pH is raised by fresh milk addition. Some whey separation will occur and is natural [13].
d. *Fruit yogurt*: Fruit, fruit syrups, or pie filling can be added to the yogurt. They are placed on top, on bottom, or stirred into the yogurt (Figure 1.7) [12].
e. *Yogurt cheese*: It is a fresh cheese made by draining overnight by separating the whey. The flavor is similar to that of a sour cream with the texture of a soft cream cheese. A liter of yogurt will yield approximately 500 mL of

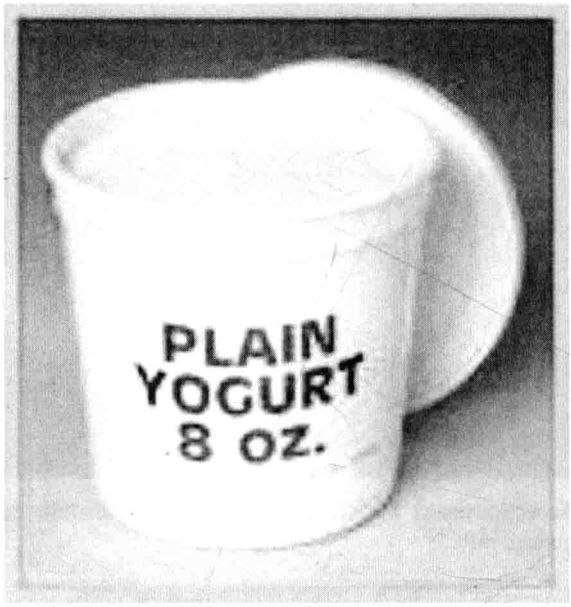

FIGURE 1.6 **(See color insert following page 212.)** Plain yogurt in consumer container.

cheese. Yogurt cheese has a shelf life of approximately 7–14 days when wrapped and placed in the refrigerator and kept at less than 4°C [15].

f. *Frozen yogurt*: After manufacturing yougurt, it is frozen by batch or continuous freezers.
g. *Dried yogurt* (Kurut in Turkey): Yogurt is sun dried for longer preservation.

FIGURE 1.7 **(See color insert following page 212.)** Low fat frozen yogurt with fruits.

1.3.2 Other Variants

Strained yogurts are types of yogurts that are strained through a cloth or paper filter, traditionally made of muslin, to remove the whey, giving a much thicker consistency, and a distinctive, slightly tangy taste. Some types are boiled in open vats first, so that the liquid content is reduced. The popular East Indian dessert, Mishti Dahi, is a variation of traditional Dahi, offers a thicker, more custard-like consistency, and is usually sweeter than Western yogurts [16].

Dadiah, or Dadih, is a traditional West Sumatran yogurt made from water buffalo milk. It is fermented in bamboo tubes [16].

Labneh is a strained yogurt used for sandwiches popular in Arab countries. Olive oil, cucumber slices, olives, and various green herbs may be added. It can be thickened further and rolled into balls, preserved in olive oil, and fermented for a few more weeks. It is sometimes used with onions, meat, and nuts as a stuffing for a variety of pies or kebabs [16].

Tarator and *Cacık* are popular cold soups made from yogurt, popular during summertime in Bulgaria, Republic of Macedonia, and Turkey. They are made with ayran, cucumbers, dill, salt, olive oil, and optionally garlic and ground walnuts [17].

Rahmjoghurt, a creamy yogurt with much higher milk fat content (10%) than most yogurts offered in English-speaking countries (Rahm is German for cream), is available in Germany and other countries [18].

Jameed is a yogurt that is salted and dried to preserve it. It is popular in Jordan.

Raita is a yogurt-based South Asian/Indian condiment, used as a sauce or dip. The yogurt is seasoned with cilantro (coriander), cumin, mint, cayenne pepper, and other herbs and spices. Vegetables such as cucumber and onions are mixed in. The mixture is served chilled. Raita has a cooling effect on the palate, which makes it a good foil for spicy Indian dishes [15].

Zabady is the yogurt made in Egypt. It is essentially famous in Ramadan fasting as it is thought to prevent feeling thirsty during fasting all day long [15].

Bihidasu, of the thicker variety of plain yogurt in Japan sold in 500 g containers, comes with a package of powdered sugar [15].

Sour cream is cultured cream and usually has a fat content of between 12% and 30%, depending on the required properties. The starter is similar to that used for cultured buttermilk. The cream after standardization is usually heated to 75–80°C and is homogenized at >13 MPa to improve the texture. Inoculation and fermentation conditions are also similar to those for cultured buttermilk, but the fermentation is stopped at an acidity of 0.6% [19].

Low-fat probiotic yogurt (commercial name Activia): Activia is a low-fat probiotic yogurt-like drink produced by a company, either a semisolid yogurt or a yogurt drink, and is sold in small and larger packages in more than 30 countries worldwide. Activia contains the probiotic bacterium *Bifidobacterium animalis*. Activia is available in plain, strawberry, raspberry, peach, mango, oatmeal, pear, walnut, coconut, vanilla, blueberry, prune, fig, pineapple, aloe vera, fibers, fruit of the forest, kiwi cereals, and rhubarb varieties, but not all varieties are available in every country [20].

Manufacturers claim that the "Bifidus Regularis" or "Bifidus Actiregularis" (both are brand names of *B. animalis*) helps digestive discomfort and irregularity [21].