

Ionel Rosenthal

# Milk and Dairy Products

Properties and Processing



VCH 

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Balaban Publishers



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*“And thou shalt have goat’s milk enough for thy food,  
for the food of thy household,  
and for the maintenance for thy maidens.”*

Proverbs 27:27

## Preface

Fifteen years ago, due to an unexpected twist in my professional career I became involved in dairy research. At that time, my knowledge of dairying was limited to a keen fondness of gourmet cheeses and in a wider context, to an amateurish interest in the science of cooking. With a strong background in chemistry and engineering, the task of comprehending the world of milk has not been easy, but nevertheless, enchanting.

Milk is a chemist's nightmare: a complex mixture of more than 100 separate substances – some dissolved, some suspended and some emulsified. Its commercial production stretches from animal science through mechanical engineering and food technology to human nutrition. By its nature, dairying combines conservative traditions with modern changes. These are enough reasons to provide challenge and fascination.

No single book can cover in depth the many facets of a subject as diverse and complex as dairying. The goal has been to produce a manageable compilation of the key knowledge on milk – sufficiently introductory to satisfy the curiosity of a neophyte and simultaneously adequate to serve as a rather short directional guide for the specialist. Deliberate attempts have been made to present the pertinent technical information in a simple readable style, with the preservation of professional respectability. Data have been gathered from extensive contact with the dairy and related industries, research in the laboratory and library, as well as teaching Dairy Science in the classroom.

Pertinent technical information has been winnowed from innumerable research publications. The documents of the International Dairy Federation summarize updated views on acute problems of the field. Milk and milk products have been more researched than most foods, and numerous text and reference books have been published on the subject. These books should be consulted by the studious reader for more details than can be presented here.

The text is organized in five chapters: composition of milk, bioproduction of milk, technology, dairy products, and miscellaneous. Chapter One introduces the chemical personality of milk: lipids, proteins, lactose and minor constituents.

The physical properties of an integral milk system are summarized, and this chapter ends with pertinent analytical methods for milk components. In Chapter Two, the milk is described in its biological context: its bioproduction by mammals, milking,

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dairy microbiology, collection and commercial value of raw milk, assertion of the quality of raw milk. Chapter Three covers the processing operations specific to the dairy industry. The removal of extraneous material by centrifugation, cream separation and standardization of fat content, bactofugation, filtration through membranes, the various heat treatments (thermization, pasteurization, sterilization) and cleaning of dairy equipment. Chapter Four is dedicated to the manufacture of dairy products: milk and milk beverages, fermented dairy products, cheeses, fat products, whey products, ice cream and dried products. This chapter also introduces a few notions of assurance of quality of dairy products, public health safety, nutritive value of milk and dietary restriction of milk products. Chapter Five is a collection of tables, charts and information which condenses data relevant to dairy.

Special thanks go to Ms. Solange Bernstein whose help, beyond the call of formal duty, was determinant in the preparation of the manuscript.

Rehovot, April 1991

Ionel Rosenthal



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# **INTRODUCTION**



## INTRODUCTION

The domestication of cattle occurred somewhere more than 6000 years ago. Sanskrit records attest to the fact that about that time, milk was already an important article of food. Milk was so valued that ancient Hindus measured wealth by the number of cattle. In time, the cow was made a sacred animal and is still so considered by a part of the population of India. The cow was also worshipped in the Middle East civilizations of about 2000 B.C. Hathor, the goddess who watched over the fertility of the land, was depicted as a cow. Milk and milk products are mentioned over fifty times in the Bible. Nearly half of these cases appear in reference to the abundance and beauty of the promised land of Israel which is described as "a land flowing with milk and honey" (Exodus 3:8,17; Numbers 13:27; Deuteronomy 6:3; Jeremiah 11:5). The milk most commonly mentioned in the Bible is that of sheep and goats (Exodus 23:19; Deuteronomy 32:14; Proverbs 27:27), but cow's milk was also known (Isaiah 7:21–22). Milk is considered among the finest of foods (Deuteronomy 32:14; Isaiah 55:1; Joel 4:18; Isaiah 60:16) and is used as a term of abundance (Joel 4:18; Isaiah 55:1), as a standard of whiteness (Genesis 49:12; Lamentations 4:7), and together with honey, as a standard of sweetness (Song of Songs 4:11). Milk was sometimes used for its calming, if not soporific, qualities (Judges 4:19).

In spite of thousands of years which have passed, milk has continued to be an important part of the human diet. Cheese was easier to keep under primitive conditions of storage and was a staple food carried by the soldiers of Genghiz Khan, the Mongol conqueror in the thirteenth century, by the Vikings in their voyages, and by the beduin nomads during desert crossings.

The technology of milk has evolved from an ancient skill to a modern technology due to pressures applied by modern society. Changes range from the very minor to those of the high-tech era, some as the result of scientific research, others by accident and experimentation. The development of rapid transport in the mid last century, artificial refrigeration which began to come into practical use between 1880 and 1890, Gail Borden's discovery of methods for condensing and canning milk in 1853 and 1862, respectively, years before Louis Pasteur discovered the causes of food spoilage, the invention of pasteurization following the discovery that certain organisms were responsible for fermentation and spoilage (L. Pasteur 1860–1864), the introduction of the first centrifugal cream separator by Carl DeLaval (1880), the Babcock-Gerber test for rapid determination of fat in milk (1890), the introduction of the phosphatase test by Kay and Graham in England in 1935 which gave health officials a reliable method for checking the thoroughness of pasteurization, introduction of ultra-

high temperature pasteurization in 1948, are a few of the benchmarks which brought the milk industry to its present level of achievement.

The applications of modern molecular biology hold promise in the 1990s for an unlimited supply of microbial "calf" rennet, genetically tailored starters and highly specific DNA probes for rapid analyses.

Today, dairy products account for a considerable part of the food supply and of prosperity and quality of life in many countries (Table).

Table. Per capita consumption (kg) of dairy products in 1987 (adapted from IDF documentation)

Country	Milk	Flavored beverages	Fermented products	Cheeses	Cream	Butter	Ice cream
Australia	96.0	9.7	3.0	8.5	1.2	6.4	7.0
Austria	134.1	2.5	9.5	9.6	1.2	8.8	6.6
Belgium	71.2	7.3	7.7	15.7	1.0	14.4	2.4
Canada	102.6	4.2	3.2	11.7	0.96	7.1	12.8 liter
Chile	17.3	0.6	3.7	3.5	0.1	0.8	
Czechoslovakia	111.7	0.3	6.1	11.8	1.2	15.0	3.1
Denmark	124.7	6.6	15.4	12.6	2.7	16.0	3.9
Finland	186.3		37.1	11.8	1.9	16.0	5.8
France	78.1	6.0	13.6	21.8	0.9	14.1	3.0
Germany	70.1	8.6	10.5	16.8	1.7	14.9	
Greece	54.2	1.7	6.0	22.2	0.3	2.7	3.5
Holland	91.2	21.0	19.1	14.9	1.0	7.2	
Hungary	101.4	10.8	2.8	9.0	1.6	5.3	0.3
India	48.3		4.2	0.2	0.02	1.1	0.03
Ireland	182.7		3.2	4.9	0.7	11.8	
Island	215.3	8.4	21.4	16.2	2.7	7.6	7.8
Italy	79.5	0.1	3.3	17.5	0.8	2.3	0.3
Japan	38.0	6.2	7.2	1.0	0.1	1.1	1.3 liter
Luxembourg	82.8	3.8	7.8	10.1	2.7	16.6	12.8
Norway	164.7		14.7	13.5	2.4	8.6	5.8
Poland	71.0		1.7	11.3	0.7	14.4	0.2
South Africa	42.7	3.8	3.4	1.5	0.3	1.1	0.3
Soviet Union	129.9		7.5	6.2	1.5	10.6	2.4
Spain	105.3	4.3	7.3	5.1	0.3	0.9	
Sweden	145.1		27.2	15.4	2.9	8.7	2.4
Switzerland	110.8	2.4	16.5	14.9	2.4	9.7	
United Kingdom	123.4	0.7	3.6	7.5	0.8	8.4	0.3 liter
USA	96.9	4.4	2.1	10.9	0.6	3.8	

Milk is a rich source of nutrients and comes close to being nature's perfect food. Scientific investigation in the field of modern nutrition has made clear the fundamental reasons why milk is an essential part of the diet under conditions of modern civilization. The proteins are of excellent quality with an excess of lysine which is important in the fortification of grain proteins. All essential vitamins are present in fresh fluid milk; it contains at least twelve water soluble and four fat soluble vitamins. The mineral content of milk, more specifically the calcium content, is a most important nutritional property of dairy products. Milk and milk products provide about 75% of the calcium in the human diet in the Western world. Lactose, which is the major component in milk, increases calcium absorption and retention. Milk fat had long been regarded as the most valuable component of milk and enjoyed an opulent reputation. Although presently it is the subject of an yet unresolved nutritional dispute, the use of milk fat should not be avoided. Studies show that dairy products, as part of a nutritionally balanced diet, do not contribute to coronary heart disease. Milk fat imparts unique functional and flavor characteristics which are not easily duplicated by other fats.

Dairy products include a wide range of foods, such as unflavored and flavored fluid milks, yogurts and other fermented products, cheeses, cream, butter, and various types of fortified, condensed and dried milk products. Milk is also an essential ingredient in many products of non-dairy origin, such as bread, cakes, cereals and pasta, sauces, gravies and soups, beverages, snack foods, sausage and imitation food products. Milk components when used as ingredients in other foods are synonymous with quality. The unique functional properties, flavor, nutrition and consumer appeal make them ideal ingredients for processed foods. Seemingly, the potential for development of new dairy and dairy-based products is unlimited.

Over the years, pride in the dairy industry caused that the craft of processing milk was looked upon as an art. Cheesemakers have done a remarkable job of producing extremely good products with skill gained through years of experience. This is a skill that lies in the fingertips, it is a feeling for the product at the various stages of production. This skill is the one thing very difficult to transfer. However, the strength of the dairy industry throughout the world lies in the continuing ability to pass on the knowledge of the "secrets of the trade". Hopefully, this book will supplement the skill with the basis for satisfying the knowledge for those inquiring.



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