BIOCHEMISTRY OF FOODS

SECOND EDITION

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Biochemistry of Foods

Second Edition

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Biochemistry of Foods

This book is dedicated to my wife,
Nella,
and our four sons,
Katriel, Joshua, Ezra, and Daniel,
and in celebration of the
ninetieth year of my mother,
Ethel Eskin

"How much better it is to get wisdom than gold,
And more desirable to get understanding than silver."
Proverbs.

Preface

Our understanding of food biochemistry has increased substantially since the publication of the first edition of this book. This has necessitated major revisions of a number of chapters plus reorganization with additional sections incorporated in the text. These changes are reflected by the four major parts in this book. Part I deals with those biochemical changes taking place in raw foods and includes four chapters. Chapter 1 discusses postmortem changes in muscle responsible for the production of edible meat and fish and includes an examination of the role of connective tissue and myofibrillar proteins in this process. Chapter 2 covers the postharvest changes in fruits and vegetables and includes a more extensive treatment of flavor and texture. Chapter 3 examines the biochemistry of cereal development with particular emphasis on wheat, and Chapter 4 reviews the complex biochemical processes involved in milk biosynthesis. Part II focuses on biochemical changes associated with processing with four areas selected. Chapter 5 covers nonenzymatic browning reactions in foods during heating and storage. Chapter 6 includes a detailed discussion of the brewing of beer, and Chapter 7 deals with the biochemistry of baking. The final chapter in this part, Chapter 8, covers the biochemistry of cheese and yoghurt. Part III deals with selected areas in the biochemistry of food spoilage with Chapter 9 on enzymatic browning and Chapter 10 on off-flavors in milk. Part IV on Biotechnology includes a detailed coverage of enzymes in the food industry, including immobilized enzymes, enzyme electrodes, and genetic engineering.

The overall organization of this edition of *Biochemistry of Foods* is far more comprehensive than the previous edition. The chapter on biodeterioration was deleted, due in part to the death of Dr. R. J. Townsend, but also because of the availability of a number of specialized books in this area. This book attempts to bridge the gap between the introductory and highly specialized books dealing with aspects of food biochemistry. It is my hope that this book will serve as a text and reference for undergraduate and graduate students, researchers, and professionals in the fields of food science, horticulture, animal science, dairy science, and cereal chemistry.

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Contents

Part I

Biochemical Changes in Raw Foods

1

Biochemical Changes in Raw Foods: Meat and Fish

I. Introduction

Meat is defined as the flesh of animals used as food. A more precise definition is provided by the U.S. Food and Drug Administration (Meyer, 1964): meat is that derived from the muscles of animals closely related to man biochemically and therefore of high nutritive value. The more conventional animal species include cattle, pig, sheep, and the avian species chicken and turkey. In fish, however, it is the white muscle which provides the main nutritional source. The per capita consumption of muscle foods in the United States has remained fairly stable as shown in Table 1.1. Beef and pork are clearly the most preferred of the muscle foods, followed by chicken and fish. In the developing continents, Africa, Asia, and Latin America, the consumption of meat and fish is still extremely low or nonexistent, as evident by the increasing incidence of malnutrition. This lack of high-grade proteins and the accompanying deficiency in essential amino acids remains the world's most urgent problem.

This chapter will discuss the dynamic changes involved in the conversion of muscle to meat or edible fish. Following the death of the animal or fish, many chemical, biochemical, and physical changes occur leading to the development of postmortem tenderness. A greater understanding of these changes should

TABLE 1.1

PER CAPITA CONSUMPTION (KG/ANNUM) OF MUSCLE FOODS BY SPECIES (USDA, 1960–76)[a]

Species	1960	1965	1970	1975
Animal source				
Beef/veal	41.5	47.5	52.7	42.0
Pork	29.5	26.6	29.7	23.2
Lamb/mutton	2.2	1.7	1.5	0.8
Avian source				
Chicken	12.6	15.1	19.0	18.3
Turkey	2.8	3.4	3.4	3.9
Aquatic source				
Fish	4.7	5.0	5.1	5.5

[a] From Sink (1979). Copyright © by Institute of Food Technologists.

make an important contribution to the production of high-quality meat or fish products.

II. The Nature of Muscle

While muscles are classified into several types, it is the striated or voluntary muscle which constitutes lean meat. The basic unit of the muscle is the fiber, a multinucleate, cylindrical cell bounded by an outer membrane, the sarcolemma. These fibers associate together into bundles, and are enclosed by a sheath of connective tissue, the perimysium. Fiber bundles are held together by connective tissue and covered by a connective tissue sheath, the epimysium. Connective tissues important to the texture and edibility of the meat and fish include fibrous proteins, collagen, reticulin, and elastin. Fish muscle has much less connective tissue, thus providing less of a problem in tenderization.

A. STRUCTURE

Individual muscle fibers are composed of myofibrils which are 1–2 μm thick and are the basic units of muscular contraction. The skeletal muscle of fish differs from that of mammals in that the fibers arranged between the sheets of connective tissue are much shorter. The connective tissue is present as short transverse sheets (myocommata) which divide the long fish muscles into seg-

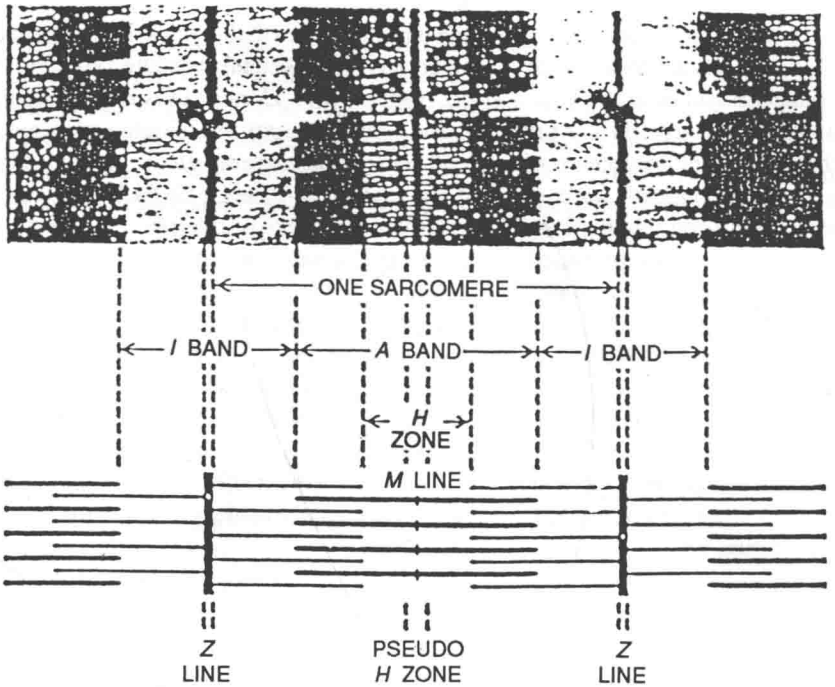

FIG. 1.1. An electron micrograph of a longitudinal section through a frog sartorius muscle is shown at the top of this figure, and a schematic diagram of the longitudinal view of the interdigitating thick and thin filament structure of the myofibril is shown at the bottom (Huxley, 1972a). Reproduced with permission of Academic Press.

ments (myotomes) corresponding in numbers to those of the vertebrae (Dunajski, 1979). The individual myofibrils are separated by a fine network of tubules, the sarcoplasmic reticulum. Within each fiber is a liquid matrix referred to as the sarcoplasm, which contains mitochondria, enzymes, glycogen, adenosine triphosphate, creatine, and myoglobin.

Examination of myofibrils under a phase contrast light microscope shows them to be cross-striated due to the presence of alternating dark or A-bands and light or I-bands. These structures in the myofibrils appear to be very similar in both fish and meat. The A-band is traversed by a lighter band or H-zone, while the I-band has a dark line in the middle known as the Z-line. A further dark line, the M-line, is observed at the center of the H-zone. The basic unit of the myofibril is the sarcomere, defined as the unit between adjacent Z-lines as shown in Figure 1.1. Examination of the sarcomere by electron microscopy reveals two sets of filaments within the fibrils, a thick set consisting mainly of myosin and a thin set containing primarily F-actin.