MEAT SCIENCE

Fifth Edition

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by

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Preface to the Fifth Edition

DURING the quarter of a century which has elapsed since the first edition of this book was published, advances in the scientific understanding of meat have been continuous and they have occurred at an accelerating rate. As a result, each subsequent edition has required a greater proportion of amendments and additions than the one before; and this applies, with particular relevance, to the latest edition. Advances in biochemistry and biophysics have further elucidated the structure and function of muscular tissue: and, reciprocally, endeavours to explain and improve the keeping and organoleptic qualities of meat have increased understanding of the biochemical differentiation of muscle both within and between species.

In the world generally, the potential of hitherto unexploited species as meat animals is being increasingly explored: in the UK continental breeds are forming a greater percentage of the total. Attempts to increase the proportion of muscular tissue in the carcass and to diminish that of fat (especially saturated fat) have become widespread; and modes of doing so (including genetic manipulation), which do not involve the use of prohibited hormones, are being sought.

Detailed studies of the structure and organization of connective tissue proteins in their various domains in muscle, of both the longer-established and the more recently discovered members of the myofibrillar proteins, and of the changes which these two protein groups undergo during pre- and post-mortem circumstances, are providing explanations for differences between muscles in the relative tenderness they exhibit as meat and establishing a basis for programmes of positive control.

Sophisticated procedures in microbiology are revealing the existence of hitherto unidentified meat spoilage organisms and pathogens, permitting a much more rapid assessment of contamination sources and levels, and providing the rationale for effective control in abattoirs, manufacturing operations and preservation. In the latter context new packaging techniques have become available which ensure longer storage life at chill temperatures and, following the report of the Advisory Committee on Irradiated and Novel Foods in 1986, there is renewed interest in the benefits of ionizing radiation as a non-additive process for preservation.

Sources in which these advances have been published are given in the present text. On the other hand, many contemporary investigations, and the publications which they have generated, have only confirmed observations which were first made many years ago. This text continues to present references to original work in preference to recent confirmatory studies unless the latter have also extended our understanding of the phenomena concerned.

These are times when it has been suggested that the consumption of meat is responsible for hypertension, carcinoma and cardiac and circulatory diseases in human consumers, on the basis of one or other of its major or minor constituents. Such generalizations, however, are not universally held, are not proven in respect of the individual consumer and tend to be ephemeral. What is irrefutable is the fact that the bodies of human beings are substantially composed of the same materials, and in the same proportions, as those of which the bulk of the carcasses of meat animals are composed. Meat, *ipso facto*, is thus a major source of nutrients for the consumer. Moreover, the ruminant, in particular, represents the only realistic mechanism for converting the sparse vegetation, which alone can grow on the vast majority of the world's usable land surface, into a nutritious and organoleptically desirable commodity–however inefficiently in comparison with plants and microorganisms. It thus seems reasonable to anticipate

a knowledge of meat science will continue to be required into the foreseeable future.

Although my specific indebtedness to individuals and organizations is indicated under "Acknowledgements", I am glad to take this opportunity of expressing my gratitude more generally for the many helpful suggestions I have received from colleagues both locally and abroad.

Sutton Bonington R. A. LAWRIE
December 1990

Preface to the First Edition

THE scientific study of food has emerged as a discipline in its own right since the end of the 1939–45 war. This development reflects an increasing awareness of the fact that the eating quality of food commodities is determined by a logical sequence of circumstances starting at conception of the animal, or at germination of the seed, and culminating in consumption. From this point of view, the food scientist is inevitably involved in various aspects of chemistry and biochemistry, genetics and microbiology, botany and zoology, physiology and anatomy, agriculture and horticulture, nutrition and medicine, public health and psychology.

Apart from the problems of preserving the attributes of eating quality and of nutritive value, it seems likely that food science will become increasingly concerned with enhancing the biological value of traditional foods and with elaborating entirely new sources of nourishment, as the pressure of world population grows. Moreover, a closer association of food science and medicine can be anticipated as another development. This will arise not only in relation to the cause or remedy of already accepted diseases, but also in relation to many subclinical syndromes which are as yet unappreciated. Such may well prevent us as individuals and as a species from attaining the efficiency and length of life of which our present evolutionary form may be capable.

Meat is one of the major commodities with which food science is concerned and is the subject of the present volume. It would not be feasible to consider all aspects of this vast topic. Instead, an attempt has been made to outline the essential basis of meat in a sequence of phases. These comprise, in turn, the origin and development of meat animals, the structural and chemical elaboration of muscular tissue, the conversion of muscle to meat, the nature of the adverse changes to which meat is susceptible before consumption, the discouragement of such spoilage by various means and, finally, the eating quality. The central theme of this approach is the fact that, because muscles have been diversified in the course of evolution to effect specific types of movement, all meat cannot be alike. It follows that the variability, in its keeping and eating qualities, which has become more apparent to the consumer with the growth of prepackaging methods of display and sale, is not capricious. On the contrary, it is predictable and increasingly controllable.

Those aspects of meat which have not been introduced in the present volume have mainly economic implications and do not involve any concept which is incompatible with the basic approach adopted. They have been thoroughly considered by other authors.

In addition to acknowledging my specific indebtedness to various individuals and organizations, as indicated in the following paragraphs, I should like to express my appreciation of the co-operation of many colleagues in Cambridge and Brisbane during the 15 years when I was associated with them in meat research activities.

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Sutton Bonington R. A. LAWRIE

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Contents

CHAPTER 1

Introduction

1.1. MEAT AND MUSCLE

Meat is defined as the flesh of animals used as food. In practice this definition is restricted to a few dozen of the 3000 mammalian species; but it is often widened to include, as well as the musculature, organs such as liver and kidney, brains and other edible tissues. The bulk of the meat consumed in the United Kingdom is derived from sheep, cattle and pigs: rabbit and hare are, generally, considered separately along with poultry. In some European countries (and elsewhere), however, the flesh of the horse, goat and deer is also regularly consumed; and various other mammalian species are eaten in different parts of the world according to their availability or because of local custom. Thus, for example, the seal and polar bear are important in the diet of the Eskimos, and the giraffe, rhinoceros, hippopotamus and elephant in that of certain tribes of Central Africa: the kangaroo is eaten by the Australian aborigines: dogs and cats are included in the meats eaten in Southeast Asia: the camel provides food in the desert areas where it is prevalent and the whale has done so in Norway and Japan. Indeed human flesh was still being consumed by cannibals in remote areas until only recently past decades (Bjerre, 1956).

Very considerable variability in the eating and keeping quality of meat has always been apparent to the consumer; it has been further emphasized in the last few years by the development of prepackaging methods of display and sale. The view that the variability in the properties of meat might, rationally, reflect systematic differences in the composition and condition of the muscular tissue of which it is the post-mortem aspect is gradually being recognized. An understanding of meat should be based on an appreciation of the fact that muscles are developed and differentiated for definite physiological purposes in response to various intrinsic and extrinsic stimuli.

1.2. THE ORIGIN OF MEAT ANIMALS

The ancestors of sheep, cattle and pigs were undifferentiated from those of man prior to 60 million years ago, when the first mammals appeared on Earth. By 2–3 million years ago the species of man to which we belong (*Homo sapiens*) and the wild ancestors of our domesticated species of sheep, cattle and pigs were probably recognizable. Man's ape-like ancestors gradually changed to human beings as they began the planned hunting of these and other animals. There are archaeological indications of such hunting from at least 500,000 B.C. It is *possible* that reindeer have been herded by dogs from the middle of the last Ice Age (about 18,000 B.C.), but it is not until the climatic changes arising from the end of this period (i.e. 10,000–12,000 years ago) that conditions favoured domestication by man. It is from about this time that there is definite evidence for it, as in the cave paintings of Lascaux.

According to Zeuner (1963) the stages of domestication of animals by man involved firstly loose contacts, with free breeding. This phase was followed by the confinement of animals, with breeding in captivity. Finally, there came selected breeding organized by man, planned development of breeds having certain desired properties and extermination of wild ancestors. Domestication was closely linked with the development of agriculture and although sheep were in fact domesticated before 7000 B.C., control of cattle and pigs did not come until there was a settled agriculture, i.e. about 5000 B.C.

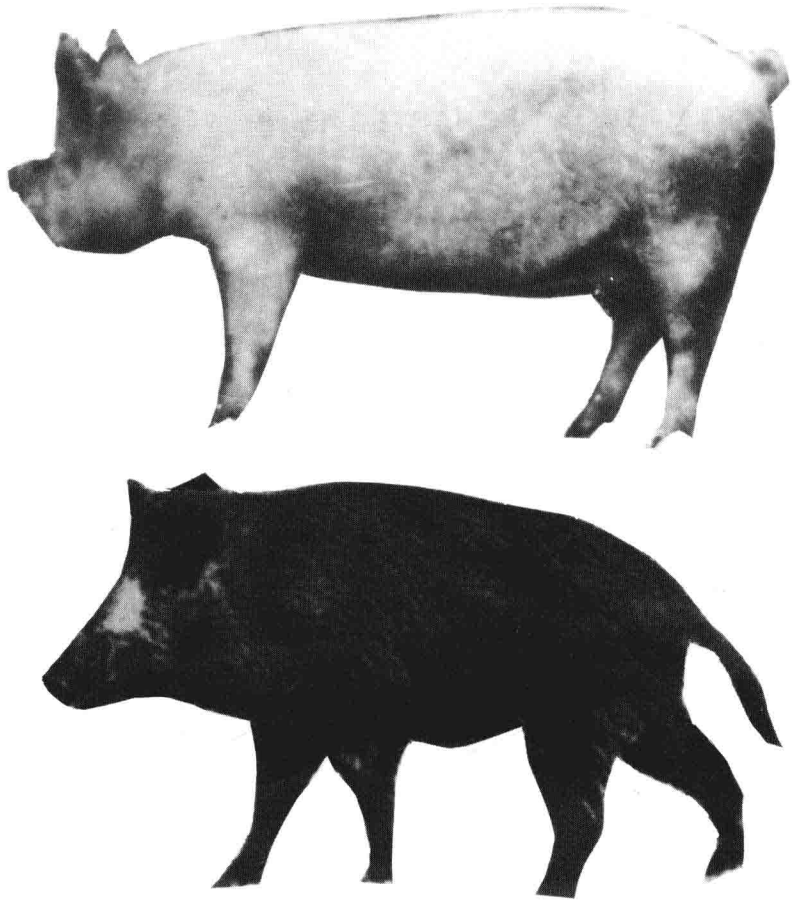

FIG. 1.1 Middle White Pig (aged 15 weeks, weighing 100 lb), and Wild Boar (adult, weighing about 300 lb), showing difference in physical characteristics. Both to same head size (Hammond, 1933–4). (Courtesy of the late Sir John Hammond.)

Domestication alters many of the physical characteristics of animals and some generalization can be made. Thus, the size of domesticated animals is, usually, smaller than of their wild ancestors. Their colouring alters and there is a tendency for the facial part of the skull to be shortened relative to the cranial portion; and the bones of the limbs tend to be shorter and thicker. This latter feature has been explained as a reflection of the higher plane of nutrition which domestication permits; however, the effect of gravity may also be important, since Tulloh and Romberg (1963) have shown that, on the same plane of nutrition, lambs to whose back a heavy weight has been strapped, develop thicker bones than controls. Many domesticated characteristics are, in reality, juvenile ones persisting to the adult stage. Several of these features of domestication are apparent in Fig. 1.1 (Hammond, 1933–4). It will be noted that the domestic Middle White pig is smaller (100 lb) than the wild boar (300 lb), that its skull is more juvenile, lacking the pointed features of the wild boar, that its legs are shorter and thicker and that its skin lacks hair and pigment.

Apart from changing the form of animals, domestication encouraged an increase in their numbers for various reasons. Thus, for example, sheep, cattle and pigs came to be protected against predatory carnivores (other than man), to have access to regular supplies of nourishing food and to suffer less from neonatal losses. Some idea of the present numbers and distribution of domestic sheep, cattle and pigs is given in Table 1.1 (Anon., 1988).