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MEAT SCIENCE

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PREFACE

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. Moreoever, 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.

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R. A. LAWRIE

Sutton Bonington, July, 1964.

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 3,000 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 Eskimoes, and the rhinoceros, hippopotamus and elephant in that of certain tribes of Central Africa: the kangaroo is eaten by the Australian aborigines and the whale in Norway and Japan; and, indeed, human flesh is still consumed by cannibals in remote areas (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 1–2 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 500000 B.C. It is *possible* that reindeer have been herded by dogs from the middle of the last Ice Age (about 18000 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.

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 that 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., 1962a).

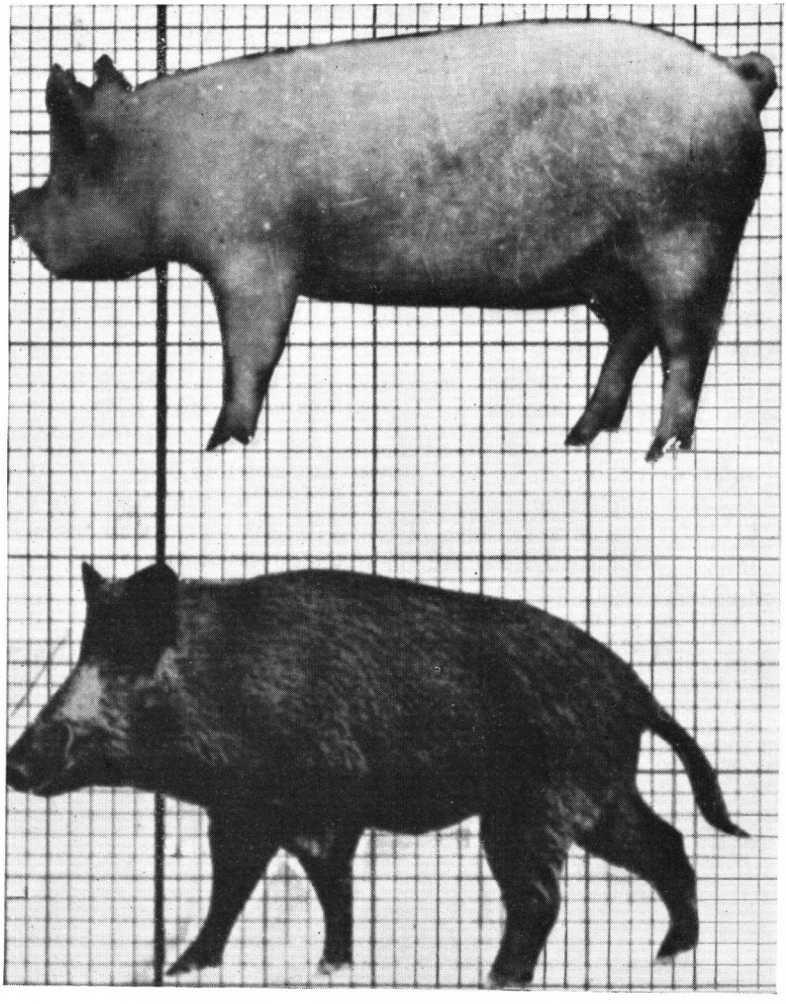

FIG. 1.1. Middle White Pig (aged 15 weeks, weighing 100 lb), and Wild Boar (adult, weighing about 300 lb), showing difference in physical characteristics. Both to same head size (Hammond, 1933-34). (Courtesy Sir John Hammond.)

TABLE 1.1. *Numbers of Sheep, Cattle and Pigs in Various Countries (1960)*

	MILLION HEAD		
	SHEEP	CATTLE	PIGS
Argentina	48·1	43·4	3·8
Australia	155·2	16·5	1·4
Denmark	—	3·4	6·2
France	9·0	19·4	8·5
Germany (West)	1·3	13·1	14·1
Hungary	2·4	2·0	5·4
Italy	8·3	9·4	4·2
Japan	—	3·2	1·9
Netherlands	—	3·5	3·0
New Zealand	47·1	6·0	0·7
Poland	3·7	8·7	12·6
Turkey	34·5	12·4	—
U.K.	27·9	11·8	5·7
U.S.A.	33·2	96·2	59·0
U.S.S.R.	136·1	74·2	53·4
Yugoslavia	11·5	5·3	6·2

The large numbers of sheep in Australia, New Zealand and U.S.S.R., of cattle in Argentina, U.S.A. and U.S.S.R. and of pigs in West Germany, Poland, U.S.A. and U.S.S.R. are noteworthy.

1.2.1. Sheep

Domesticated sheep belong to the group *Ovis aries* and appear to have originated in western Asia. The sheep was domesticated with the aid of dogs before a settled agriculture was established. Four main types of wild sheep still survive—the Moufflon in Europe and Persia, the Urial in western Asia and Afghanistan, the Argali in central Asia and the Big Horn in northern Asia and North America. In the United Kingdom, the Soay and Shetland breeds represent remnants of wild types.

By 3500–3000 B.C. several breeds of domestic sheep were well established in Mesopotamia and in Egypt: these are depicted in archaeological friezes. Domestication in the sheep is often

associated with a long or fat tail and with the weakening of the horn base so that the horns tend to rise much less steeply. The wool colour tends to be less highly pigmented than that of wild sheep.

Nowadays, about forty different breeds of sheep exist in the United Kingdom. Some of these are shown in Table 1.2.

TABLE 1.2. *Some Breeds of Sheep found in the United Kingdom (after Gerrard, 1951)*

(a)	HILL BREEDS			
	Scotch Blackface	Cheviot	Welsh Mountain	Lonk
	Herdwick	Derbyshire Gritstone	Penistone	Rough Fell
	Swaledale	Limestone	Exmoor Horn	Dartmoor
	Kerry Hill	Radnor	Soay	Shetland
(b)	LONG WOOL BREEDS			
	Leicester	Romney Marsh (Kent)	Border Leicester	Lincoln
	Devon Longwood	South Devon	Wensleydale	Roscommon Cotswold
(c)	DOWN BREEDS			
	Southdown	Suffolk	Oxford Down	Hampshire Down
	Dorset Down	Shropshire Down	Dorset Horn	Ryeland

The improved breeds, such as the Suffolk, tend to give greater acrcase yield than semi-wild breeds such as the Soay or Shetland sheep, largely because of their increased level of fatness (Hammond, 1932a). Again, of the improved breeds, those which are early maturing, such as the Southdown and Suffolk, have a higher percentage of fat in the carcase than later maturing breeds, such as the Lincoln and Welsh; moreover, the subcutaneous fat appears to increase, particularly in the former. The English mutton breeds (e.g. Southdown and Cotswold) have a greater development of subcutaneous connective tissue than wool breeds, e.g. Merino. The coarseness of grain of the meat from the various breeds tends to be directly related to overall size, being severe in the Large Suffolk sheep: the grain of