DEVELOPMENTS IN FOOD PROTEINS—3

DEVELOPMENTS IN FOOD PROTEINS—3

Edited by

B. J. F. HUDSON

Senior Research Fellow, Department of Food Science, University of Reading, UK

ELSEVIER APPLIED SCIENCE PUBLISHERS
LONDON and NEW YORK

ELSEVIER APPLIED SCIENCE PUBLISHERS LTD
Ripple Road, Barking, Essex, England

Sole Distributor in the USA and Canada
ELSEVIER SCIENCE PUBLISHING CO., INC.
52 Vanderbilt Avenue, New York, NY 10017, USA

British Library Cataloguing in Publication Data

Developments in food proteins.—3
1. Food—Protein content—Periodicals
I. Title
641.1'2'05 TX553.P7

ISBN 0-85334-271-7

WITH 43 TABLES AND 57 ILLUSTRATIONS

Printed in Great Britain by Galliard (Printers) Ltd. Great Yarmouth

CONTENTS OF VOLUMES 1 AND 2

Volume 1

Volume 2

PREFACE

As in the two previous volumes, I have aimed at offering a balanced selection of food protein topics, whether they are based on protein sources, techniques of investigation or aspects important to the consumer. The subject continues to attract major research and development resources and it is therefore not difficult to choose new features regularly.

The earlier volumes had little to say about meat. Here the balance is redressed with a general introduction, emphasising compositional aspects, in Chapter 1, and a more specialised theme, which discusses the role of haemoproteins in meat quality, in Chapter 2. Milk proteins appear again, with reference to cheese processing and texture, in Chapter 3.

Sunflower seed, now one of the world's most important crops, is potentially a rich source of protein as well as oil, but, as shown in Chapter 4, the protein seems to be still under-exploited. Moving to 'unconventional' protein sources, biotechnology is now offering a new source in the form of bacterial protein. The possibilities of this development are discussed in Chapter 5.

The rapidly developing newer chromatographic techniques of analysis are applicable in the investigation of food proteins, peptides and amino acids, as is shown in Chapter 6.

The nutritional aspects of food proteins always attract attention but unhappily they are not always positive. The negative aspects, which are of equal importance to the food producer, are the subject of Chapters 7 and 8. The former informs readers of the many complex artefacts that arise in the course of food processing and storage, and the latter discusses those proteins of natural occurrence in foods that elicit unfavourable physiological responses.

Once more, my sincere thanks are due to the ten authors who have contributed so enthusiastically to making the production of this volume possible, and to the publisher for advice and encouragement.

B. J. F. Hudson

LIST OF CONTRIBUTORS

U. Faust

Hoechst AG, Zentralforschung II—Biotechnik, 6230 Frankfurt-am-Main 80, Postfach 80 03 20, Federal Republic of Germany

P. F. Fox

Department of Dairy and Food Chemistry, University College, Cork, Republic of Ireland

Angharad M. R. Gatehouse

Department of Botany, University of Durham, Science Laboratories, South Road, Durham DH1 3LE, UK

R. F. Hurrell

Nestlé Products Technical Assistance Co. Ltd, CH-1814 La Tour-de-Peilz, Switzerland

D. A. Ledward

Department of Applied Biochemistry and Food Science, University of Nottingham, Sutton Bonington, Loughborough LE12 5RD, UK

R. Macrae

Department of Food Science, University of Reading, London Road, Reading, Berks, RG1 5AG, UK

M. D. Ranken

Michael Ranken Services, 9 Alexandra Road, Epsom, Surrey KT17 4BH, UK

U. SCHARF
Hoechst AG, Zentralforschung II - Biotechnik, 6230 Frankfurt-am-Main 80, Postfach 80 03 20, Federal Republic of Germany

M. SCHLINGMANN
Hoechst AG, Zentralforschung II - Biotechnik, 6230 Frankfurt-am-Main 80, Postfach 80 03 20, Federal Republic of Germany

FRANK W. SOSULSKI
Department of Crop Science, University of Saskatchewan, Saskatoon, Saskatchewan, Canada S7N 0W0

CONTENTS

Chapter 1

COMPOSITION OF MEAT: SOME STRUCTURAL AND ANALYTICAL IMPLICATIONS

M. D. RANKEN*

Michael Ranken Services,
Epsom, Surrey, UK

SUMMARY

Although meat consists largely of protein it is not just protein, even less 'a protein'. It contains a number of proteinaceous structures comprising muscle, connective and fatty tissues, each of which also contains non-protein material. Some of these structures are still far from well described or understood.

Variability in the composition of meat appears mainly as a result of differing proportions of these various tissues in different animals or, more importantly, in different parts of the same animal. If the origin of a specimen of meat is precisely known its composition may also be accounted for fairly precisely. Where the origin is unknown an analyst can proceed only by making assumptions about the average composition of meat, which may be correct on the average and in the long run but which are subject to unknown, sometimes large, errors in individual cases. Where the legal control system rests on some definition of 'meat', as in Britain, this poses severe problems in enforcement. Where control is based on analytical parameters the legal problems may appear to be smaller but the variability remains.

* Previously: Head, Meat and Fish Products Section, Leatherhead Food Research Association, Randalls Road, Leatherhead, Surrey KT22 7RY.

INTRODUCTION

Meat is a major source of food protein. In most countries, excepting only those where large scale poverty and malnutrition do not permit much interest in foods as relatively expensive as meat, or where the culture is traditionally vegetarian, meat is held in high esteem socially, as a sign of good living, and nutritionally, as a food which is good for you.

Meat is mainly protein but we know that it is not exclusively protein. We also know that meat contains not one but very many different proteins and that in some ways the diversity among them is of critical importance. These many different components are also well known to be structurally ordered in a complex manner.

The purpose of this brief review is to describe some of the influences which the diversity and complexity of meat composition have upon the basic simple relationship between 'meat' and 'protein'. In particular, we shall examine the question which must be asked by the analyst – if it is possible to discover the protein content of a sample, what does that tell us about the meat content?

We should define our terms. In the UK, though the legal position is not absolutely clear, 'meat' is effectively defined as 'the flesh, including fat, and the skin, rind, gristle and sinew in amounts naturally associated with the flesh used, of any animal or bird which is normally used for human consumption, and includes cured meat, permitted offal, tail, feet, sweetbreads and tripe...'.[1]

The German definition is 'all parts of warm blooded animals slaughtered or killed as game and intended for human consumption' and for the manufacture of meat product including skeletal muscles together with associated fatty and connective tissue, nerves, lymph nodes, vessels and pig salivary glands.[1]

A Russian definition is 'the animal carcass from which the hide, head, extremities and internal organs (thoracic and abdominal) have been removed'.[2]

The American definition is 'The part of the muscle of any cattle, sheep, swine, or goats, which is skeletal or which is found in the tongue, in the diaphragm, in the heart or in the esophagus, with or without the accompanying and overlying fat and the portions of bone, skin, sinew, nerve and blood vessels which normally accompany the muscle tissue ...'.[1]

All of these definitions effectively mean that meat is the material which a butcher could remove from a carcase with a knife (including some but not all of the offals) intending that it will be eaten as food. Fat and connective tissue are included along with the muscle tissues and the definitions are a long way from any simple equation of 'meat' with 'protein'.

'Meat' in these general, butchers' or 'commonsense' definitions is not equated exclusively with 'lean meat' or muscle, even though that component is the one which most people seem to like the best.

CARCASE COMPOSITION

There is a wealth of information concerning the quantity of 'meat' to be obtained from different kinds of animal: brief but useful summaries will be found in standard texts such as Lawrie[3] or review papers.[4] The actual data to be found there are of marginal value to our present interest, but it is useful to appreciate how even at this early stage in the production of meat, questions directly related to the quantity and distribution of the proteins are raised and dealt with.

In the experimental work two kinds of factor are related to one another:

(i) Data relating to overall weights of the animals: liveweight gains during the growing period, sometimes feed conversion efficiencies (of great interest as measures of the efficiency of conversion of vegetable or cheap animal protein into higher class animal protein), and dressing-out percentages or the conversion of live animal weight to carcase weight.

(ii) The proportions of lean meat or muscle, fatty tissue and bones obtained by dissection of the dressed carcases. The dissection may be done according to the anatomical form of the animal or according to some relevant commercial butchery practice, in any case it is often difficult to relate one set of experimental data with another because of differences in the dissection techniques used. Hides of cattle or skins of sheep are not usually included in this information, being removed at the dressing-out stage and counted there, but the skin or rind of pork is normally left on the carcase, regarded as edible and may be reported in the carcase yield data.

The most important of the factors influencing the quantities and the proportions of muscle and the other meat components available are: (a) the animal species; (b) the breed; (c) age at slaughter; (d) nutrition of the animal.

Age at slaughter. This strongly influences the proportion of muscle. The growth which occurs in well nourished animals up to the age of puberty is predominantly in the form of expansion of the muscles of the skeleton—the proportion of muscle increases up to a maximum while the proportion of bone diminishes. Providing the animal is not over-fed the proportion of fat on the carcase remains small. After puberty the development of new muscle comes to an end, though replacement continues throughout life, and any further weight increase is largely in the form of deposits of fat. There are small changes with age in the quantity of connective tissues and significant changes in their quality, which will be considered in a later paragraph.

Nutrition of the animal. There is for each breed, species, etc. a level of feeding and a relationship between protein, carbohydrate and fat in the diet conducive to optimum weight of the animal and optimum proportion of muscle in the carcase.

Carcase Grade describes the degree to which the carcase conforms to the accepted commercial optimum, usually as defined by the grower. It appears to be related mainly to the fat content of the carcase.

There is considerable interest in using measurements which can be made on the live animal or on the just-slaughtered carcase to predict the proportion of lean meat which it will yield.[5] The thickness of the fat layer on the back, especially with pigs, is one such predictor. It may be measured in a variety of ways, including optical probes on the intact carcase, direct measurement on a cut carcase or ultrasonic probe on the live animal. Density measurement of the carcase can give a good measure of fat content in practice, X-ray measurements can also do so in experimental conditions but apparently not yet in commercial practice. Even visual assessment, especially if it is done against previously carefully made diagrams or photographs, can give a very useful approximation.

COMPOSITION OF MEAT CUTS

Apart from significant differences among the species of meat animals, the major variations in the proportions of lean, fat, connective tissue and bone are those which occur in different parts of the carcase of the same animal. Compared with this, factors such as age, breed or nutrition contribute very little to the overall variation. This factor is however both quantitatively and qualitatively very important. Table 1 shows some typical analytical values for cuts of beef: obviously not all of the cuts from a carcase have been included.

'Noble' cuts of meat, in the language of high-class chefs, are those which are the most highly regarded, because they contain high proportions of muscle or lean meat, not too much fat, with that fat mainly on the outside of the meat where it can easily be removed if it is not wanted, low contents of connective tissue, none of which is in the form of large, thick pieces of

TABLE 1
COMPOSITION OF BEEF CUTS
(from Danilov[2])

Cut	*Composition, % by weight of carcase*			
	Muscle	*Fatty tissue*	*Connective tissue*	*Bone*
More noble				
Sirloin	65·8	11·4	9·6	13·2
Rump	66·5	9·9	10·3	13·3
Less noble				
Chuck	63·4	7·3	12·4	16·9
Blade	57·4	16·1	10·6	15·9
Neck	48·4	7·9	18·5	25·2
Flank	57·9	16·7	24·8	0·6

gristle and, finally, either no bone or else bones which are also large and relatively easily removed. Meat with these properties is easily cooked by simple procedures such as grilling or roasting, to give tender portions, easily cut and served, consisting wholly or mainly of the most desirable lean meat. It will be appreciated that these cuts are associated with the lower back and hindquarters of an animal, where the muscles and the bones are large and the individual movements made in the live animal are relatively simple. Connective tissues, both those associated with muscle sheaths and those of tendons and ligaments, are therefore relatively small in quantity and this feature is associated with tenderness of the meat following simple rapid cookery.

The less 'noble' meat, on the other hand, comes from the parts of the animal where the movements to be made by the head, neck and fore limbs are relatively delicate and complex. The structure of the bones and musculature necessary to accomplish the movements is therefore one of small, complex units. The connective tissues around and between the muscles, together with intermuscular fat, are greater in quantity and the bones are correspondingly difficult to remove from the meat. Meat from the belly region has little content of bones but the connective tissues of the belly wall are specially thick and strong. Meat from these regions requires slow, moist cookery to hydrolyse and soften the collagen and because of its general form and the problems of bone removal it is not possible to serve it in large attractive pieces.

But the less 'noble' meat is undeniably 'meat', even if it contains more fat and connective tissue than the 'noble' meat, and it remains both costly to produce and of high nutritional value when appropriately handled and cooked. Some of the masterpieces of *haute cuisine* can be seen to originate directly in solutions to problems of preparing and cooking and serving such meat attractively.

A significant part of meat product manufacture is also designed to treat the less 'noble' meat in ways which will convert it into materials acceptable to consumers, and not waste it. In temperate climates such as in Britain, where there is relatively little need to avoid spoilage and wastage of meat in hot weather by manufacturing meat products of long shelf life,[6] utilising both 'noble' and less 'noble' meats, there is instead a tendency to ensure that the majority of 'noble' meat is used for domestic and prestige cookery, leaving the less 'noble' to be used undiluted in comminuted or cooked products. This in turn leads to a psychological reinforcement of the differences in 'nobility' and ultimately to a feeling, undeclared and unjustifiable, that the meat used in meat products is less good 'meat' than the meat which is not.

There is an analogous question, perhaps more evident, concerning the use of meat offals. All of the animal offals are or have been used in human food,[7] but their actual acceptability is always a matter of local culture, probably influenced by the prevailing standard of living. As we saw in the Introduction, many of the offals are formally regarded as 'meat', even in advanced countries, but they are certainly not always as acceptable to ordinary consumers as the best steak.

Blood is commonly counted among the offals, but its protein content is high and its nutritional value in cases of iron deficiency is very high. It is a major ingredient of black puddings or blood sausages, the popularity of which seems to be declining in many western countries.[8] The content of residual blood in meat after slaughter is variable but may be about 1 %,[9] and because it thus occurs naturally within ordinary meat it is considered to fall, at any rate to that extent, within the legal meaning of 'meat' in the UK.

There are likely to be analytical difficulties in accounting for the material we call 'meat', however we choose exactly to define it, on account of quite wide variations in gross composition among actual portions of meat. The variability is partly a consequence of real differences in function, structure and composition of the meat in different parts of the animal body. It may also partly arise out of uncertainties about which of the edible portions of an animal body we are prepared to include in our definition of 'meat'. In both cases we are aware of subjective tendencies to limit our acceptance of the term 'meat' to materials with some narrower range of variability than actually is to be found over the whole range of acceptable animal tissues.

STRUCTURE AND COMPOSITION OF MUSCLE

Muscle consists of the mechanism by which the live animal moves. It is very highly organised for that function. Figure 1 shows, in a simplified form, something of the high degree of order involved. The structures are almost entirely, but not completely, composed of protein. Movement is provided by the system of actin and myosin in the myofibrils, sliding into or outwards

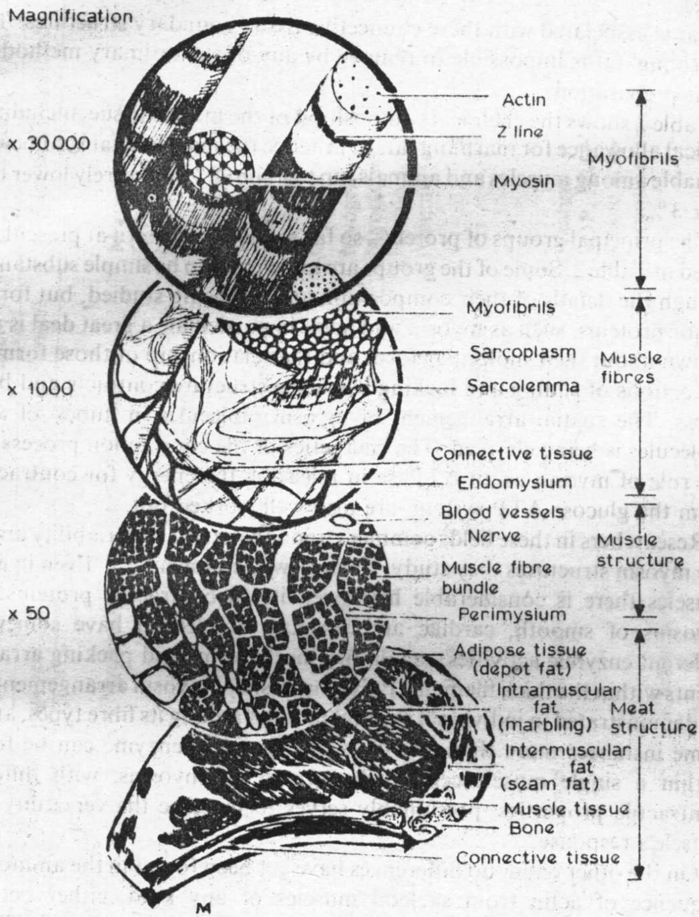

FIG. 1. Structure of meat at various magnifications (from Ref. 1, with the permission of the Controller of Her Majesty's Stationery Office).