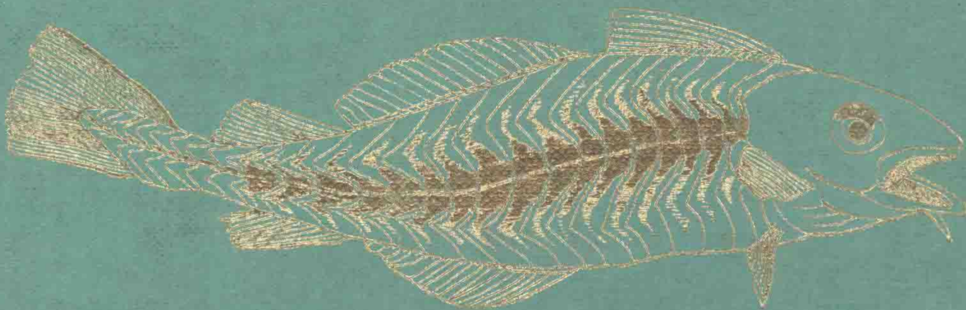
# The FOOD FISHES

their intrinsic variation and practical implications



R. Malcolm Love

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# The
# FOOD FISHES

*This book is dedicated to*
*Bob Anderson, Jack Lavéty and Ian Robertson,*
*who have been my colleagues, friends and*
*shipmates over so very many years.*

# Foreword

*by*

Professor J.J. Connell, C.B.E.

The fish industry has to cope with a number of unique difficulties, one of the most important being intrinsic variability of its raw material. Fish vary enormously in size, shape, microbiology, parasitology, chemistry and biochemistry, and it is with the last two areas that Dr. Love's book deals. Chemical and biochemical variations in fish have, of course, often been described. Dr. Love's aim is, however, not to assemble more tables of values but to explain variability in terms of underlying physiological changes, of external influences and of biochemical responses to them. Understanding such principles in depth can provide us with a much more powerful tool for fashioning technological change than would a bare collection of descriptions.

Systematic studies of the numerous phenomena involved are scattered widely through the literature, and only someone like Dr. Love who has made a scholarly and painstaking effort to collate the mass of information, most of it recent, could have written such an original work. The book will be of special interest to scientists who advise industrialists and official bodies on the utilisation of fish as food, and in order to facilitate the readers' task Dr. Love has in many places drawn out commendably practical conclusions. It will, therefore, contribute valuably to the technology necessary to get fish products of better and more uniform quality to the consumer.

# Preface

Much has been written on the quality of fish as a foodstuff. Many factors combine to influence its deterioration after death, and workers from laboratories all over the world have studied them, endeavouring to retard or eventually eliminate spoilage.

In this account I have adopted a different stance, and deal instead with variations in the quality of the fish at the point of capture, showing also how they may affect the processing properties. It would be a mistake to assume that the quality of newly captured fish is perfect, and that all the undesirable features develop later. This assumption is not valid, because the living fish can vary a great deal in the attributes that make up 'quality' or that influence subsequent changes.

The existence of considerable differences between marine fish caught at different times of year or on different grounds has always been accepted by fishermen and processors. For centuries it has been known that the oil content of herrings decreases at certain times, and that as a result the salted or smoked products become less appetising. There are, however, other kinds of variability, long known within the industry, on which systematic studies have been carried out only comparatively recently.

In my laboratory, the effects of natural variation were first encountered when experiments on the freezing and cold storage of cod yielded contradictory results because of seasonal vagaries in the raw material. The extent of cold-storage deterioration had been assessed from a reduction in the extractability of the contractile proteins into salt solution, but the extractability also differed 'naturally', for example between cod caught in September and in October on the same ground (Ironside and Love, 1958).

Observations of variations in fish according to fishing ground are reported from time to time, usually without explanation. Some intriguing examples can be quoted.

Cod caught on the North Cape Bank of Norway spoil more rapidly from bacterial action than those caught on the Faroe Bank when both are packed in melting ice (Reay, 1957). The trimethylamine oxide content of haddock and cod from arctic waters is higher than that of similar fish from the North Sea (Anon., 1950), as is the vitamin A content of halibut livers (Lovern, Edisbury and Morton, 1933). It is widely known within the British fish industry that cod from Bear Island sometimes gives off a distinctive 'weedy' smell and those from Spitzbergen smell of iodine from time to time. The guts of a giant catfish can smell of rotten eggs, but only when the fish are caught off Madagascar (Bykov, 1984). One of our experiments showed that when cod fillets were cooked and eaten, the flesh of a particular batch caught off St. Kilda (western Scotland) was consistently tougher than that of a batch from west Greenland (Love, 1975).

Fish kept in the frozen state gradually develop both an off-odour and an off-flavour, and K.J. Whittle (unpublished, quoted by Love, 1975) found that those caught on the Faroe Bank develop these characteristics to a far greater extent than those caught elsewhere. A further personal recollection is the disappointment at finding that the large haddocks caught off Iceland and cooked on the ship tasted of fairly average cotton wool or paper pulp in contrast to the smaller versions caught off Aberdeen which were succulent and sweet.

Our studies on a large number of fish have shown that characteristics important to the consumer (flavour, odour, texture, smooth cut surface, flesh colour, skin colour and also the extent and nature of deterioration) can all vary according to where or when the fish were caught. This account describes the variations and their causes. Awareness of particular variations engenders vigilance among those who handle fish commercially, while understanding their mechanisms might enable action to be taken to minimise their effects.

It will be noticed that the observations recorded above tend to be of an 'anecdotal' nature, though they are nevertheless real. Only if proper systematic research is done can otherwise random phenomena become predictable. Such research is complicated whenever there are interactions among the causative factors.

The purpose of this book is to draw together, for the first time, a mass of hitherto unconnected material from widely differing sources. By describing in detail the causes of variability in newly-caught fish, I hope that the reader will be better able to understand the variations in his own raw material, bearing in mind that extrapolations from observations on one species to those of another can be risky.This is especially true where knowledge has been obtained from exotic species which differ markedly from the common 'food' species. However, it has to be said that many important discoveries have been made in fish physiology using non-food species - lungfish, guppies, sticklebacks and so on. For me to have omitted the information solely because such fish had been used for the experiments would have left serious gaps in the body of revealed knowledge, and I have therefore used *all* findings relevant to my arguments.

The subject-matter is not confined to simple observations and their practical consequences. Such an approach would be naive, and the uninformed reader could misinterpret related phenomena. I have therefore described in some detail the background to the observations and the nature of the tissue we are dealing with, often in the light of very recent research work.

Maturation, for example, has perhaps the most far-reaching effects on the properties of the edible part of the fish, so the background to it is described in depth - how it is triggered each year, how different hormones interact to govern maturation and so on. Steps necessary for the alleviation of 'gaping' are listed - and therefore the nature and causes of gaping are discussed. Natural variations in the responses of fish muscle to cold storage are described, so the nature of freezing is also considered. Chapters are rounded off with a section entitled 'Technological Perspectives'. This is intended to concentrate the information of potentially practical benefit diffused through the detailed material. It is hoped that fish biologists and physiologists will find much of interest in the bulk of any chapter, but each final section is directed especially to the food scientists and technologists and - dare I hope? - it might bring the chapter into focus for students of food science, catering, nutrition and aquaculture.

The farming of fish is at present increasing throughout the world, and much research effort is devoted to the breeding of hardy stocks which utilise food with maximum efficiency. If the quality of the fish produced were to deteriorate so as to compare unfavourably with that of wild fish, the entire industry would be severely damaged. Here I hope to anticipate potential problems so that quality can be maintained in the future, especially during cold storage. As more and more farmed fish are produced, the trend to freeze a bigger proportion of the harvest can be expected to continue.

Identifying fish by their full Latin names can make the text rather unwieldy, so I have used only common names in the text, unless one common name refers to more than one species, for example different species of tilapia, or where I have been able to find only the Latin name. Otherwise, except in the tables, the Latin names have been banished to the Appendix, where the exact identification can be established.

Occasionally I have quoted the same experimental finding in more than one place: this is to enable each section to be reasonably complete.

Readers accustomed to a watertight basis for all conclusions may feel sometimes that I extrapolate existing evidence too freely. This policy has been quite deliberate, and is intended to point the way, via incomplete work, to potentially useful research projects in the field of food science. So many interesting findings lurk around the corner that it seems worthwhile to suggest some directions that future investigations might take.

The word idem (Latin: 'same') is used to attribute a further observation or conclusion to an author or authors mentioned immediately above.

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All other Figures and Tables originated in this laboratory, and are Crown Copyright. Several authors kindly supplied original photographs; these are acknowledged in the legend to each Figure.

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# Contents

## Part II: Aspects of Quality

## Part III: Environmental Factors

# Part I: The Fish Themselves

# 1. The Physical Structure of Fish Muscle and its Chemistry

Fish musculature is not a uniform material, but contains varying proportions of three principal tissues: white (fast) muscle, dark (red or slow) muscle and connective tissue. Apart from possessing numerous minor components, all three are composed of proteins, lipids and water, but the proportions differ in each, sometimes widely, and the subcomponents of the proteins and lipids also differ among themselves. It is because workers in the past tended to regard fish muscle as uniform that they took little regard of which part of the fillet they sampled for analysis; consequently, their results were sometimes not meaningful, and could not be compared with those of other workers.

## A. White Muscle

The main bulk of any fillet is white muscle. In some species, for example salmon and trout, the equivalent tissue is known as mosaic muscle, white and dark cells being found together. The muscle can be seen with the naked eye to consist of tiny thread- like cells, about the thickness of human hairs. In the living state they can contract or relax so that the fish swims; they are the very stuff of which the fish is made. Changes in their properties affect the texture of the cooked or raw fish as it is chewed, and if the fillet has toughened too much, it is these cells or bundles of cells that tend to lodge between the teeth of the eater.

Each cell is surrounded by a very thin composite membrane, the cell wall, within which are the subunits of the cell, the myofibrils, which run parallel inside the parent cells. The myofibrils in turn consist of thick and thin 'myofilaments', which can be seen only with an electron microscope at high magnification. The myofilaments are composed of protein molecules, and it is at this level that the actual mechanism of muscle contraction takes place, the thick and thin filaments sliding along each other. There is much more to the fine structure of fish muscle, but this is all that needs concern us here. Only the solid ('structural') components contribute to the resistance felt in chewing.

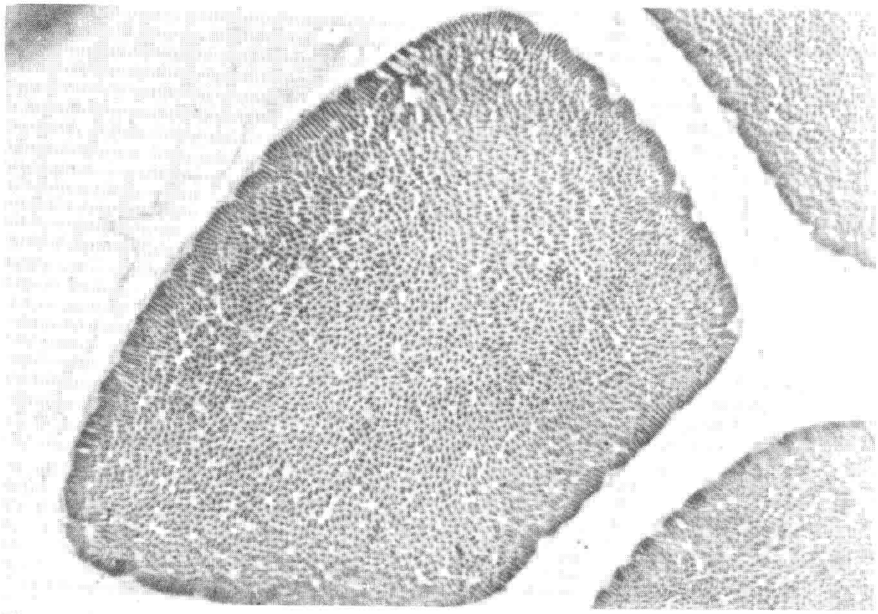

Fig. 1. Cross-section of a single cod muscle cell, showing the relative sizes of the myofibrils. The peripheral myofibrils are ribbon-shaped in this species. Unstained, phase-contrast illumination, x 400. Photograph kindly supplied by Mr Peter Howgate. Crown copyright.

A cross section of a single fish muscle cell (Fig. 1) shows the relative sizes of variously shaped myofibrils in relation to the whole cell. Myofilaments are shown in Fig. 34 on page 65. When fish muscle has toughened from excessive cold storage, individual cooked cells remain intact during eating and may be swallowed together in bundles. On the other hand, the cells of tender cooked fish are easily separated from one another and at least some may be broken down to myofibrils in the mouth. We do not need to consider the myofilaments in the context of texture as sensed during eating, except to say that they are the ultimate solid components of fish muscle.