Seafood Processing

Adding Value Through Quick Freezing, Retortable Packaging, and Cook-Chilling

V. Venugopal

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To My Parents

Foreword

The international seafood industry is faced with interesting complexities and many contradictions, such as the following:

Seafood is among the most internationally traded food product categories, but it is also among the most perishable and requires flawless distribution chain management.

Value addition through processing is the key to success, but often the least prepared seafood — fresh or even live from the sea — fetches the highest price.

Seafood is a valuable part of a healthy diet but consumers lack the skills and confidence to prepare it.

Health authorities advise increased fish consumption but production is constrained by sustainability issues in the capture fisheries and environmental concerns in aquaculture.

How does the seafood industry operate within these apparent contradictions and constraints? There is no simple answer, except to say that it is driven by the market pull that is created by increasingly health conscious consumers, sound technology in processing, modern logistics, and not the least by across-the-world cooperation of production and marketing people who face the everyday challenges of the business with enthusiasm and expertise.

Value addition is an important term for the modern food business. Traditionally, it has been thought of as a processing term, that is, adding value to basic foods by means of coating, combination of ingredients, processing, and convenient presentation. The driving force for value is, however, created in the market by the consumer who finds the product to have added value as per his or her circumstances. It is therefore appropriate to think of value primarily as a marketing term and in each instance based on consumer perception.

Worldwide, marketing people agree that the trends driving the demand for seafood in years to come and in the major markets are closely tied to trends in lifestyles, which seem remarkably similar in many areas of the world. Across the globe, these driving forces originate in the need and desire of the human race when it is presented with a wide choice of food and a reasonable income, and they are manifested in the quest for convenience in preparation, product quality, and the healthy image that seafood has gained in terms of nutritive value, and even special health benefits.

This book brings together a wealth of information on seafood processing and consumption. It provides an overview for the global fisheries production and consumption pattern, highlights the nutritional importance of fishery products, and

also discusses perishability and the biohazards associated with seafood as well. It gives a thorough description of processing technologies for quick freezing, cook-chilling, and retort pouch packaging, among others with a briefer look at smoking and canning.

In short, this book will greatly help to explain how the seafood industry operates quite successfully in spite of the contradictions mentioned above, but primarily it will serve as an expert source on modern processing technology for seafood.

Alda B. Möller
Food Scientist
Seafood Industry Consultant, Iceland

The Author

Dr. V. Venugopal received his M.Sc. (Chemistry) from the University of Kerala and Ph.D. (Biochemistry) from the University of Bombay. He began his career at the Central Institute of Fisheries Technology, Cochin, India, and later moved to the Bhabha Atomic Research Center, Mumbai, where he was head of the Seafood Technology Section of the Food Technology Division. He has been a postdoctoral research fellow at the National Institutes of Health, Bethesda, Maryland, U.S. and a Visiting Scientist at the Memorial University of Newfoundland, St. John's, Newfoundland, Canada. His main interests were value addition of fishery products, radiation processing of fishery products, role of bacterial proteases in fish spoilage, and gelation of fish muscle proteins. He has published more than 120 publications in these areas, which included research papers, review articles, and book chapters. He is a Fellow of the National Academy of Agricultural Sciences, New Delhi, India.

Preface

With changes in life styles, consumers' perception of processed food is also changing. As a consequence there is an increasing demand for convenient, nutritive, and safe foods all over the world. In addition, consumers are aware of the nutritive value of food and the effects of processing on it. These changes have caused more and more agricultural products to enter international trade in processed form rather than as raw commodities. This scenario indicates prospects for novel techniques of value addition that can add convenience, novelty, and marketability to products without causing significant losses in their nutritive value. Minimal processing techniques including nonthermal methods and techniques that are less harsh in their thermal effects are gaining importance to satisfy the needs of modern consumers.

Seafoods, which traditionally were traded in bulk consignments without much serious processing, can attract novel processing techniques. The time has arrived for the fishery sector to take advantage of the outlook of the modern consumer to capture wider markets through process-diversification techniques. The 1980s saw seafood items getting increasing media attention as a source of valuable nutrients. Greater demands for fishery products, diminishing marine landings, and depletion of certain fish stocks have resulted in rapid rise in fish production by farming techniques. However, currently most farmed items are marketed with negligible levels of value addition. As observed recently by Prof. J.M. Regenstein, Cornell University (*Food Technol.*, 58, 28, 2004), if the fishery industry is to compete with other food industries more creativity will be needed in their processing and marketing. Because of its diversity in composition, seafood offers scope for a wide range of product forms having diverse flavors. Success of the seafood industry in the coming years lies in the judicious application of value addition methodologies to develop products that are nutritive, tasty, appealing, and stable for extended storage, supported by marketing strategies. Developments in minimal processing, nonthermal methods, or methods that are less harsh allow processing of seafood without much adverse impact on their flavors and contents of essential nutrients. These methods, which rely heavily on principles of physics, chemistry, and microbiology, include irradiation, high hydrostatic pressure, antimicrobials, ultrasound, pulsed electric light, and oscillatory magnetic fields. In this book, an attempt has been made to focus the upcoming technologies for value addition of marine and aquacultured fishery products. The introductory chapter is devoted to briefly discuss the current global status of seafoods, consumption pattern, and to highlight prospects for value addition. This is followed by two chapters, one that discusses perishability and biohazards associated with the commodity, and the other discusses the bulk

handling and chilling of fishery products. The remaining part of the book discusses different process technologies for value addition. Conventional techniques such as smoking and canning have not been discussed separately; but briefly dwelt upon in relevant chapters. At the end, a chapter is devoted to highlighting the nutritional importance of fishery products including the influence of processing on its nutritive value. An appendix provides some information related to seafood processing.

This book would not have been possible without the initial guidance and support I received from a number of my former esteemed colleagues, the late Dr. A.N. Bose, the late Prof. A. Sreenivasan, the late Dr. U.S. Kumta, and the late Dr. V.K. Pillai. Drs. S. Ayyappan and K. Gopakumar have extended encouragement in writing this book. Dr. K. Devadasan, Director, Central Institute of Fisheries Technology (CIFT), India, was generous in extending his valuable library facilities. Ms. V. Muralidharan, J. Joseph, T.K. Sreenivas Gopal, P.K. Surendran, S.P. Garg, Ms. Sailaja of CIFT; D.R. Bongirwar, S.B. Warrier and S.V. Ghadhi of BARC; Dr. A.K. Bhargava, Fishery Survey of India, and S. Mathew have shared with me useful information that is included in this book. I also thank the library authorities of Bhabha Atomic Research Centre and University Institute of Chemical Technology, Mumbai. I am obliged to K.K. Balachandran, former principal scientist, CIFT, for going through the manuscript critically and offering suggestions. I am thankful to many individuals outside India who have provided valuable information, which were included in specific chapters. These persons include Drs. Paw Dalgaard and K.N. Jensen of the Danish Institute of Fisheries Research, Denmark; Phil Bremer from University of Otago, Dunedin, New Zealand, Dr. S. Rodgers, University of Western Sydney, Australia; Dr. N. Hedges of Unilever Research, Sharnbrook, U.K.; and Dr. N. Krishnasamy, Infofish, Kuala Lumpur, Malaysia. My former student, Dr. R. Lakshmanan, University of Glasgow, Scotland, U.K., deserves special mention for his continued interest and support during the preparation of the book. I appreciate the interesting pictures on impingement freezing system and *surimi* products sent by Ms. Rikard Jevinger, Frigoscandia, Sweden and Peter Lammertyn, *Viciunai*, Lithuania. I am also grateful to my family members—my wife, Rema for her patience and support, Prakash and Laxmi for their help at various stages of the work, and Hari, Shyamsundar, and Srikant for their excellent computer support. My special thanks are due to Ms. Susan B. Lee and Ms. Randy Brehm of CRC Press and Mr. K. Mohankumar, Newgenimaging Systems, Chennai, India for their valuable editorial support. I welcome suggestions from readers to improve the contents of the book and correct any inadvertent errors.

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1 Availability, Consumption Pattern, Trade, and Need for Value Addition

1.1 Introduction

The term "seafood" generally refers to a variety of groups of biologically divergent animals consisting not only of fish, whether of freshwater, estuarine, or marine habitats, but also of shellfish which include crustacea and mollusks. The crustacea comprises of crayfish, crab, shrimp, and lobster, while the mollusks could be bivalves such as mussel, oyster, and scallop, univalve creatures such as abalone, snail, and conch, and cephalopods which include squid, cuttlefish, and octopus. Fisheries provide a vital source of food, employment, trade, and economic well-being for people throughout the world. In the early 1970s fish was considered as a resource against hunger in the world. Presently, fish has gained importance as a health food, because several species have been identified as rich in easily digestible proteins containing all the essential amino acids, therapeutically important polyunsaturated fatty acids, in addition to calcium, iodine, vitamins, and many other nutrients. Fishery products constitute a major portion of international trade, which is a valuable source of foreign exchange to many developing countries. Fisheries sector enjoys some advantages over other animal production systems. First, fish is the cheapest source of animal protein and a health food. Second, high fecundity (up to 1 million eggs) and fast growth rate of fishes have no parallel among other animal protein sources, like livestock including poultry. These biological advantages offer considerable benefits to fish as a tool to achieve nutritional and social security. While contribution of agriculture to gross domestic product (GDP) is decreasing all over the world, that of fisheries is increasing in most countries.

1.2 Availability of Fishery Products

Fish makes a very significant contribution to the diets of many communities in both the developed and developing worlds. According to the State of World Fisheries and Aquaculture, 2002, published by the Food and Agriculture Organization (FAO) of the United Nations, more than one billion people worldwide rely on fish as an important source of animal proteins, deriving at least 20% of protein from fish.[1] This share could exceed 25% in poor countries and could be much higher in isolated

TABLE 1.1
Capture Production (in tons) by Some Major Groups of Species During the Years 2000 and 2002

Species group	2000	2002
Carps, barbels, and other cyprinids	570,965	592,962
Tilapia and other cichlids	680,066	682,639
Salmons, trouts, smelts	805,139	806,998
Flounders, halibuts, soles	1,008,471	918,840
Cods, hakes, haddocks	8,673,042	8,392,479
Miscellaneous coastal fishes	6,039,972	6,471,124
Herring, sardines, anchovies	20,628,706	22,472,563
Tunas, bonitos, billifishes	5,828,375	6,088,337
Sharks, rays, chimaeras	857,749	818,542
Freshwater crustaceans	568,469	818,993
Lobsters, spiny-rock lobsters	222,052	222,132
Shrimps, prawns	2,949,714	2,979,336
Oysters	249,647	186,699
Mussels	276,276	264,101
Scallops	660,700	747,516
Clams	798,339	825,651
Squids, cuttlefish, octopuses	3,660,404	3,173,272
Freshwater mollusks	595,286	633,561
Miscellaneous marine mollusks	1,497,351	1,491,849

Source: Adapted from FAO, *FAO Yearbook, Fishery Statistics, Capture Production*, Vol. 94/1. Food and Agriculture Organization, United Nations, Rome, Italy, 2002. With permission.

parts of coastal or inland areas in some countries. For example, the proportion of animal protein derived from marine products in the diet of the population in West Africa is as high as 63% in Ghana, 62% in Gambia, and 47% in Senegal.[2] However, in the course of the last four decades, the share of fish proteins to animal proteins has exhibited a slight negative trend due to a faster growth in consumption of other animal products.[1]

1.2.1 Capture Fisheries

The fish landings in the world has increased from 39.2 mt in 1961 to 122.1 mt in 1997 (at an annual growth rate of 3.6%), while food fish supply has grown from 27.6 mt to nearly 94 mt during the same period.[1] The landings were 130.9 mt and 132.9 mt in 2000 and 2002, respectively.[1] World fish production of finfish remained relatively stagnant at around 130 mt for the last few years.[1] Table 1.1 indicates world landings of major groups of fishery products in recent years. Two thirds of the total food fish supply is from marine and inland water fisheries.[1] The