MICROBIOLOGY OF MARINE FOOD PRODUCTS

MICROBIOLOGY OF MARINE FOOD PRODUCTS

Edited by

Donn R. Ward
Department of Food Science
North Carolina State University

Cameron Hackney
Department of Food Science and Technology
Virginia Polytechnic Institute and State University

An avi Book
Published by Van Nostrand Reinhold
New York

An AVI Book
(AVI is an imprint of Van Nostrand Reinhold)

Library of Congress Catalog Number 90-37357
ISBN 0-442-23346-9

Printed in the United States of America

Van Nostrand Reinhold
115 Fifth Avenue
New York, New York 10003

Chapman and Hall
2-6 Boundary Row
London SE1 8HN, England

Thomas Nelson Australia
102 Dodds Street
South Melbourne 3205
Victoria, Australia

Nelson Canada
1120 Birchmount Road
Scarborough, Ontario M1K 5G4, Canada

16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1

Library of Congress Cataloging-in-Publication Data
Microbiology of marine food products / edited by Donn R. Ward and
Cameron R. Hackney.
p. cm.
"An AVI book."
Includes bibliographical references and index.
ISBN 0-442-23346-9
1. Seafood—Microbiology. 2. Seafood—Safety measures. I. Ward,
Donn R., 1949– . II. Hackney, Cameron Ray.
QR118.M53 1991 90-37357
576'.163—dc20 CIP

Microbiology of Marine Food Products

Preface

In recent years, consumption of seafood products has risen dramatically. However, along with the growth in consumption, there has been growing enthusiasm for efforts to improve the quality and the perceived safety of seafoods. This has culminated in the debate on "Mandatory Seafood Inspection." While *quality* and *safety* are the principal issues behind the inspection debate, microbiology is one of the principal sciences associated with quality and safety.

All food commodities have their own distinctive microbiology. However, of all the food commodities, seafoods have one of the most, if not *the* most, diverse and complex microbiologies. Unlike meat or poultry products where only a few species are represented in each group, the term seafoods encompasses hundreds of genera and species. Concerns associated with mollusks are often quite different from those associated with finfish or crustaceans. Other factors contributing to the microbiological complexity are the range of environmental habitat (freshwater to saltwater; tropical waters to arctic waters; pelagic swimmers to sessile bottom dwellers) and processing practices (iced fresh products to commercially sterile canned products; hand labor to mechanized processes).

This book provides a comprehensive examination of microbiological quality and safety concerns of seafood from harvest through processing. Many of the chapters are the most comprehensive reviews to date. A concerted effort has been made to incorporate discussions on topics that are both timely and timeless. Examples of the former include "U.S. Seafood Inspection and HACCP" and "Vibrionacae," whereas examples of the latter include "Irradiation" and "Packaging." There are also topics which are not necessarily "microbiological" in nature, but are important to any meaningful discussion on seafood safety; these include: "Parasites," "Natural Toxins," "Thermal Processing," and "Depuration."

This book views seafood microbiology from the perspectives of environmental influences and processing influences. It will hopefully serve as a stimulus for future research in these two areas, and bring the questions of quality and safety into a proper perspective.

Contributors

Linda S. Andrews, M.S.
Department of Food Science
Louisiana State University
Baton Rouge, LA 70803

Tuu-Jyi Chai, Ph.D.
Seafood Science Program
Horn Point Environmental Laboratories
University of Maryland
Cambridge, MD 21613

Ralph R. Cockey
Seafood Science Program
Horn Point Environmental Laboratories
University of Maryland
Cambridge, MD 21613

Mary T. Cole, M.S.
Department of Biology
Nicholls State University
Thibodaux, LA 70310

David W. Cook, Ph.D.
Gulf Coast Research Laboratory
Ocean Springs, MS 39564-7000

Thomas L. Deardorff, Ph.D.
Department of Structural and Cellular Biology
College of Medicine
University of South Alabama
Mobile, AL 36688

George J. Flick, Ph.D.
Department of Food Science and Technology
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061

E. Spencer Garrett, M.S.
National Marine Fisheries Service
National Seafood Inspection Laboratory
Pascagoula, MS 39568-1207

Robert M. Grodner, Ph.D.
Department of Food Science
Louisiana State University
Baton Rouge, LA 70803

Cameron R. Hackney, Ph.D.
Department of Food Science and Technology
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061

Sherwood Hall, Ph.D.
Food and Drug Administration
Washington, DC 20204

Martha Hudak-Roos
National Marine Fisheries Service
National Seafood Inspection Laboratory
Pascagoula, MS 39568-1207

Steven C. Ingham, Ph.D.
Applied Microbiology and Food Science
University of Saskatchewan
Saskatoon, Saskatchewan S7N OWO
Canada

Howard Kator, Ph.D.
School of Marine Science
Virginia Institute of Marine Science
College of William and Mary
Gloucester Point, VA 23062

Marilyn B. Kilgen, Ph.D.
Department of Biology
Nicholls State University
Thibodaux, LA 70310

John E. Kvenburg, Ph.D.
Division of Microbiology
Food and Drug Administration
Washington, DC 20204

Lucina E. Lampila, Ph.D.
Seafood Experiment Station
Virginia Polytechnic Institute
and State University
Hampton, VA 23669

Brian K. Mayer, M.S.
Campbell Soup Company
Camden, NJ 08103-1799

Russell J. Miget, Ph.D.
Texas A&M Marine Advisory Service
Port Aransas, TX 78373

Robin M. Overstreet, Ph.D.
Gulf Coast Research Laboratory
Ocean Springs, MS 39564-7000

Alvin P. Rainosek, Ph.D.
University of South Alabama
Mobile, AL 36688

Martha W. Rhodes, M.S.
School of Marine Science
Virginia Institute of Marine Science
College of William and Mary
Gloucester Point, VA 23062

Gary P. Richards
National Marine Fisheries Service
Southeast Fisheries Center
Charleston Laboratory
Charleston, SC 29412-0607

Thomas E. Rippen, M.S.
Seafood Experiment Station
Virginia Polytechnic Institute
and State University
Hampton, VA 23669

Gary E. Rodrick, Ph.D.
Department of Food Science
and Human Nutrition
University of Florida
Gainesville, FL 32611

Jayne E. Stratton
Department of Food Science
and Technology
and Food Processing Center
University of Nebraska
Lincoln, NE 68583-0919

Steve L. Taylor, Ph.D.
Department of Food Science
and Technology
and Food Processing Center
University of Nebraska—Lincoln
Lincoln, NB 68583

Donn R. Ward, Ph.D.
Department of Food Science
North Carolina State University
Raleigh, NC 27695-7624

Contents

Part 3 Special Processing and Packaging

Part 1

Seafood Quality

1

Microbiology of Finfish and Finfish Processing

Brian K. Mayer and Donn R. Ward

Finfish are generally regarded as being much more perishable than other high-protein muscle foods. This high degree of perishability is due primarily to the large concentration of nonprotein nitrogenous compounds present in fish muscle. These compounds, which include free amino acids and volatile nitrogen bases such as ammonia, trimethylamine, creatine, taurine, the betaines, uric acid, anserine, carnosine, and histamine are utilized actively by bacteria during spoilage (Jay 1986). Another factor that contributes to the perishability of finfish is the temperature of the water from which they are harvested. The bacterial flora of cold-water fish species are not inhibited as effectively by refrigeration as are the normal flora of fish harvested from warm tropical waters. When handled properly, tropical fish species are generally less prone to rapid spoilage and exhibit a longer refrigerated shelf life than cold-water species (Disney 1976; Poulter et al. 1981; Sumner et al. 1984). This broad generalization, however, may have to be reconsidered. A review by Lima dos Santos (1981) on the storage of tropical fish on ice contends that there are too many variables for direct comparisons, and that there are instances of cold-water fish such as halibut and grenadiers having a shelf life, on ice, for up to 3 weeks.

It is generally accepted that the internal flesh of live, healthy fish is sterile. The natural bacterial flora reside mainly in the outer slime layer of the skin, on the gills, and in the intestines of feeding fish. Bacterial numbers range from 10^2 to 10^6 colony forming units (cfu) per square centimeter on the skin, on the gills from 10^3 to 10^5 per gram, and in the intestine from very few in nonfeeding fish to 10^7 or greater in feeding fish (Liston et al. 1976). These initial microflora are directly related to the environment, whereas the total microbial load is subject to seasonal variation (Liston 1956; Shewan 1961). Shewan (1977) indicated that warm-water fish seem to have a more mesophilic, Gram-positive microflora (micrococci, bacilli, coryneforms), whereas cold-water fish harbor a predominately Gram-negative psychrophilic population (*Moraxella, Acinetobacter, Pseudomonas, Flavobacterium,* and *Vibrio*). Regardless of the differences in the initial microflora, the spoilage patterns of finfish during iced storage are usually quite similar and are caused by *Pseudomonas* spp. and *Alteromonas putrefaciens* (Barile et al. 1985b). This chapter will discuss the factors that affect the growth and invasion of these spoilage bacteria during harvesting and processing and ultimately affect quality.

HARVESTING AND ONBOARD HANDLING

The initial quality and microbial load of fresh finfish is affected by the method of harvesting. It is at this point that quality maintenance must begin. Abusive handling at harvest will be detrimental to subsequent quality and shelf life at the retail level.

A wide variety of fishing gear and methods are employed to harvest finfish commercially. These include traps and barriers, hook and line techniques, and various types of nets (Alverson 1976). Although little quantitative data are available to compare the microbial load of freshly landed fish by different harvesting methods, Shewan (1949) demonstrated that trawled fish usually carry microbial loads that are 10–100 times greater than those of line-caught fish. This increase is attributed to dragging along the ocean bottom, which stirs up the mud and contaminates the fish, and to compaction of the fish, which causes gut contents to be expressed. When trawling for fish, it is generally accepted that longer tows will result in lower quality (Costakes et al. 1982). During periods of heavy fishing the cod end of the net becomes very full and the resulting catch, which may have been dead for hours, is bruised and crushed from compression. Furthermore, larger catches take longer to stow properly. The fish are therefore subjected to the physical abuse of sliding on the boat deck and exposure to ambient temperature and sunlight. In this case fishing for quantity adversely affects quality.

The amount of stress that the fish endures during capture, just prior to death, has also been shown to affect postharvest quality. Fish that are normally very active, such as tuna and mackerel, may become excited and die in a frenzied state when harvested by purse-seining. Inherent physiological features of tuna make them unique from other fish species. They are among the fastest swimming fish, with burst speeds for yellowfin *(T. albacores)* reported as 21 body lengths per second (Walters and Fierstine 1964). Tuna have very high metabolic rates and some species have the ability to adjust their body temperature. When tuna are captured in a highly stressed state, the buildup of lactic acid in the muscle combined with elevated muscle temperature results in a serious flesh defect known as burnt flesh (Goodrick 1987). The flesh is no longer bright red and the flavor is acidic with a metallic aftertaste. In this state the tuna is still acceptable for canning but unacceptable for the highly lucrative Japanese sashimi market. For this reason, longlining is the desired harvesting method for minimizing stress and maintaining postharvest quality of tuna.

The effect of stress on postharvest quality has been documented with other