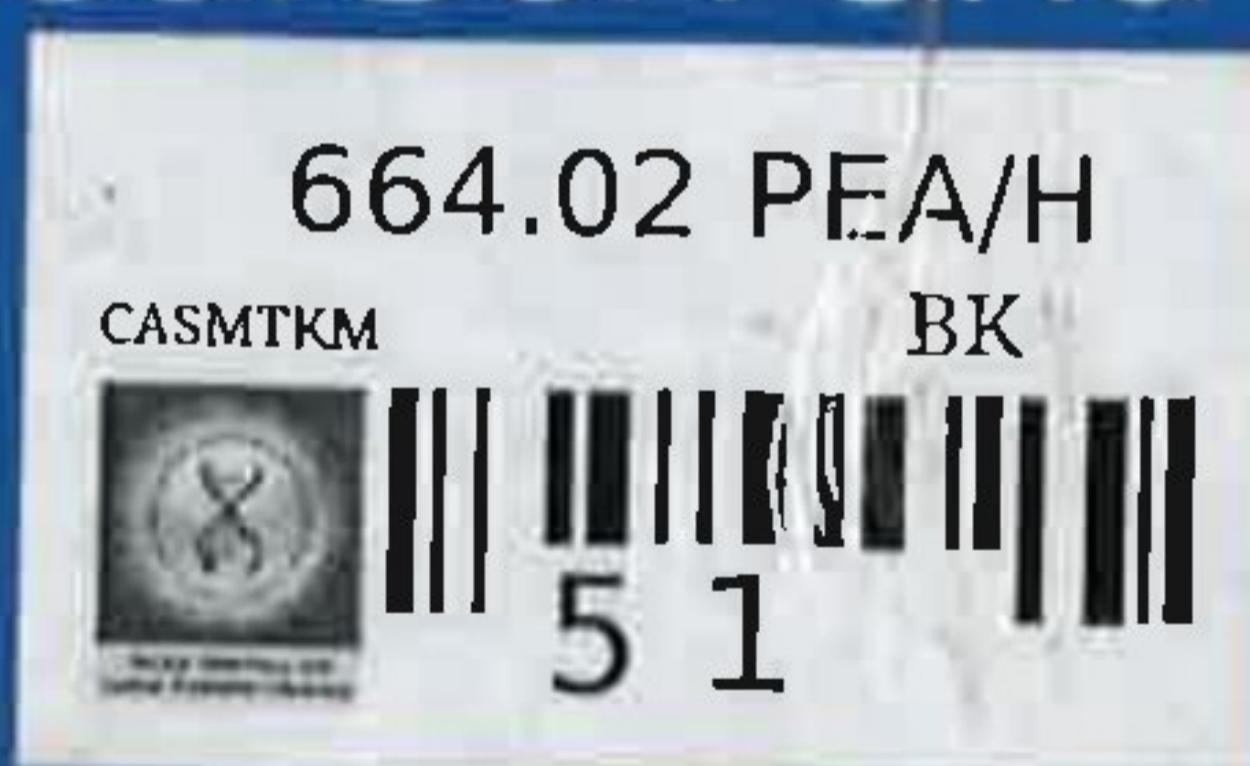


HACCP IN MEAT, POULTRY AND FISH PROCESSING

ADVANCES IN MEAT RESEARCH SERIES VOLUME 10

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AN ASPEN PUBLICATION

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- GAO (1993) *Food Safety: A Unified, Risk-Based System Needed to Enhance Food Safety*. General Accounting Office. GAO/T-RCED-97-71. Washington, D.C.
- NACMCF (1990a) *Refrigerated Foods Containing Cooked, Uncured Meat or Poultry Products that are Packaged for Extended Refrigerated Shelf Life and that are Ready-to-Eat or Prepared with Little or No Additional Heat Treatment*. National Advisory Committee on Microbiological Criteria for Foods. United States Department of Agriculture, Washington, D.C.
- NACMCF (1990b) *Cooked Ready-To-Eat Shrimp, Cooked Ready-To-Eat Crab Meat*. National Advisory Committee on Microbiological Criteria for Foods. United States Department of Agriculture, Washington, D.C.
- NACMCF (1991) *Listeria monocytogenes*. The National Advisory Committee on Microbiological Criteria for Foods. *Intl. J. Food Microbiol.* 14, 185.
- NACMCF (1992a) Microbiological criteria for raw molluscan shellfish. The National Advisory Committee on Microbiological Criteria for Foods. *J. Food Prot.* 55, 463.
- NACMCF (1992b) Hazard analysis and critical control point system. The National Advisory Committee on Microbiological Criteria for Foods. *J. Food Microbiol.* 16, 1.
- NACMCF (1993a) *Campylobacter jejuni/coli*. The National Advisory Committee on Microbiological Criteria for Foods. United States Department of Agriculture, Washington, D.C.
- NACMCF (1993b) The role of regulatory agencies and industry in hazard analysis and critical control point system. The National Advisory Committee on Microbiological Criteria for Foods. *Intl. J. Food Microbiol.* 21, 187.
- NACMCF (1993c) Generic HACCP for raw beef. The National Advisory Committee on Microbiological Criteria for Foods. *Food Microbiol.* 10, 449.
- NPR (1993) *From Red Tape to Results: Creating a Government that Works Better and Costs Less*. The Report of the National Performance Review. The White House, Washington, D.C.
- NRC (1985) *An Evaluation of the Role of Microbiological Criteria for Foods and Food Ingredients*. Subcommittee on Microbiological Criteria, Committee on Food Protection, Food and Nutrition Board, National Research Council. National Academy Press, Washington, D.C.
- USCFTA (1988) *United States-Canada Free-Trade Agreement implementation Act of 1988*. Pub. L. No. 100-499. Section 406. United States Government Printing Office, Washington, D.C.
- USDA (1992) *Minutes of the Meeting of the National Advisory Committee on Microbiological Criteria for Foods*. United States Department of Agriculture, Washington, D.C.
- USDA (1993) *Food Safety Offensives*. News Release No. 0417.93. Office of Public Affairs, News Division, United States Department of Agriculture, Washington, D.C.
- USDA (1994) *The National Advisory Committee on Microbiological Criteria for Foods. Departmental Regulation No. 104328*. United States Department of Agriculture, Washington, D.C.

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HACCP in Meat, Poultry and Fish Processing

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Since its development by The Pillsbury Company as part of the US space program, the HACCP (hazard analysis critical control point) system has become the most important technique for the identification and prevention of foodborne biological, chemical and physical hazards in food processing.

This book presents the latest information on the HACCP concept and gives practical examples of its implementation at all stages of food production and processing from the farm to the consumer. In addition, guidelines are given for the management of the HACCP system within the food industry and how it can be incorporated into a total quality management program. The role of predictive microbiology in HACCP is examined and the relationship of HACCP principles to existing and future international agreements and regulations is explained.

This book is essential reading for quality control personnel, production and processing managers in the food industry, and for government regulatory officials. It will also be of interest to academic researchers studying the microbiology and quality of meat, poultry and fish products.

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