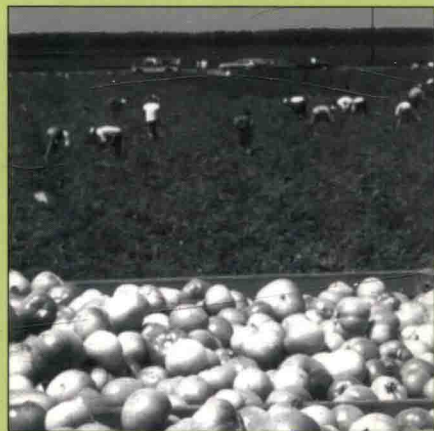


Postharvest Physiology and Pathology of Vegetables

Second Edition, Revised and Expanded



edited by
Jerry A. Bartz
Jeffrey K. Brecht

Postharvest Physiology and Pathology of Vegetables

Second Edition, Revised and Expanded

edited by

Jerry A. Bartz
Jeffrey K. Brecht

*University of Florida
Gainesville, Florida, U.S.A.*



MARCEL DEKKER, INC.

NEW YORK • BASEL

Library of Congress Cataloging-in-Publication Data

A catalog record for this book is available from the Library of Congress.

The first edition was published as *Postharvest Physiology of Vegetables*, edited by J. Weichmann.

ISBN: 0-8247-0687-0

This book is printed on acid-free paper.

Headquarters

Marcel Dekker, Inc.

270 Madison Avenue, New York, NY 10016

tel: 212-696-9000; fax: 212-685-4540

Eastern Hemisphere Distribution

Marcel Dekker AG

Hutgasse 4, Postfach 812, CH-4001 Basel, Switzerland

tel: 41-61-260-6300; fax: 41-61-260-6333

World Wide Web

<http://www.dekker.com>

The publisher offers discounts on this book when ordered in bulk quantities. For more information, write to Special Sales/Professional Marketing at the headquarters address above.

Copyright © 2003 by Marcel Dekker, Inc. All Rights Reserved.

Neither this book nor any part may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, microfilming, and recording, or by any information storage and retrieval system, without permission in writing from the publisher.

Current printing (last digit):

10 9 8 7 6 5 4 3 2 1

PRINTED IN THE UNITED STATES OF AMERICA

Postharvest
Physiology
and
Pathology of
Vegetables

FOOD SCIENCE AND TECHNOLOGY

A Series of Monographs, Textbooks, and Reference Books

EDITORIAL BOARD

Senior Editors

Owen R. Fennema University of Wisconsin–Madison
Marcus Karel Rutgers University (emeritus)
Gary W. Sanderson Universal Foods Corporation (retired)
Pieter Walstra Wageningen University
John R. Whitaker University of California–Davis

Additives **P. Michael Davidson** University of Tennessee–Knoxville
Dairy science **James L. Steele** University of Wisconsin–Madison
Flavor chemistry and sensory analysis **John H. Thorngate III** University of California–Davis
Food engineering **Daryl B. Lund** University of Wisconsin–Madison
Health and disease **Seppo Salminen** University of Turku, Finland
Nutrition and nutraceuticals **Mark Dreher** Mead Johnson Nutritionals
Phase transition/food microstructure **Richard W. Hartel** University of Wisconsin–Madison
Processing and preservation **Gustavo V. Barbosa-Cánovas** Washington State University–Pullman
Safety and toxicology **Sanford Miller** University of Texas–Austin

1. *Flavor Research: Principles and Techniques*, R. Teranishi, I. Hornstein, P. Isenberg, and E. L. Wick
2. *Principles of Enzymology for the Food Sciences*, John R. Whitaker
3. *Low-Temperature Preservation of Foods and Living Matter*, Owen R. Fennema, William D. Powrie, and Elmer H. Marth
4. *Principles of Food Science*
Part I: Food Chemistry, edited by Owen R. Fennema
Part II: Physical Methods of Food Preservation, Marcus Karel, Owen R. Fennema, and Daryl B. Lund
5. *Food Emulsions*, edited by Stig E. Friberg
6. *Nutritional and Safety Aspects of Food Processing*, edited by Steven R. Tannenbaum
7. *Flavor Research: Recent Advances*, edited by R. Teranishi, Robert A. Flath, and Hiroshi Sugisawa
8. *Computer-Aided Techniques in Food Technology*, edited by Israel Saguy
9. *Handbook of Tropical Foods*, edited by Harvey T. Chan
10. *Antimicrobials in Foods*, edited by Alfred Larry Branen and P. Michael Davidson
11. *Food Constituents and Food Residues: Their Chromatographic Determination*, edited by James F. Lawrence
12. *Aspartame: Physiology and Biochemistry*, edited by Lewis D. Stegink and L. J. Filer, Jr.

13. *Handbook of Vitamins: Nutritional, Biochemical, and Clinical Aspects*, edited by Lawrence J. Machlin
14. *Starch Conversion Technology*, edited by G. M. A. van Beynum and J. A. Roels
15. *Food Chemistry: Second Edition, Revised and Expanded*, edited by Owen R. Fennema
16. *Sensory Evaluation of Food: Statistical Methods and Procedures*, Michael O'Mahony
17. *Alternative Sweeteners*, edited by Lyn O'Brien Nabors and Robert C. Gelardi
18. *Citrus Fruits and Their Products: Analysis and Technology*, S. V. Ting and Russell L. Rouseff
19. *Engineering Properties of Foods*, edited by M. A. Rao and S. S. H. Rizvi
20. *Umami: A Basic Taste*, edited by Yojiro Kawamura and Morley R. Kare
21. *Food Biotechnology*, edited by Dietrich Knorr
22. *Food Texture: Instrumental and Sensory Measurement*, edited by Howard R. Moskowitz
23. *Seafoods and Fish Oils in Human Health and Disease*, John E. Kinsella
24. *Postharvest Physiology of Vegetables*, edited by J. Weichmann
25. *Handbook of Dietary Fiber: An Applied Approach*, Mark L. Dreher
26. *Food Toxicology, Parts A and B*, Jose M. Concon
27. *Modern Carbohydrate Chemistry*, Roger W. Binkley
28. *Trace Minerals in Foods*, edited by Kenneth T. Smith
29. *Protein Quality and the Effects of Processing*, edited by R. Dixon Phillips and John W. Finley
30. *Adulteration of Fruit Juice Beverages*, edited by Steven Nagy, John A. Attaway, and Martha E. Rhodes
31. *Foodborne Bacterial Pathogens*, edited by Michael P. Doyle
32. *Legumes: Chemistry, Technology, and Human Nutrition*, edited by Ruth H. Matthews
33. *Industrialization of Indigenous Fermented Foods*, edited by Keith H. Steinkraus
34. *International Food Regulation Handbook: Policy • Science • Law*, edited by Roger D. Middlekauff and Philippe Shubik
35. *Food Additives*, edited by A. Larry Branen, P. Michael Davidson, and Seppo Salminen
36. *Safety of Irradiated Foods*, J. F. Diehl
37. *Omega-3 Fatty Acids in Health and Disease*, edited by Robert S. Lees and Marcus Karel
38. *Food Emulsions: Second Edition, Revised and Expanded*, edited by Kåre Larsson and Stig E. Friberg
39. *Seafood: Effects of Technology on Nutrition*, George M. Pigott and Barbee W. Tucker
40. *Handbook of Vitamins: Second Edition, Revised and Expanded*, edited by Lawrence J. Machlin
41. *Handbook of Cereal Science and Technology*, Klaus J. Lorenz and Karel Kulp
42. *Food Processing Operations and Scale-Up*, Kenneth J. Valentas, Leon Levine, and J. Peter Clark
43. *Fish Quality Control by Computer Vision*, edited by L. F. Pau and R. Olafsson
44. *Volatile Compounds in Foods and Beverages*, edited by Henk Maarse
45. *Instrumental Methods for Quality Assurance in Foods*, edited by Daniel Y. C. Fung and Richard F. Matthews
46. *Listeria, Listeriosis, and Food Safety*, Elliot T. Ryser and Elmer H. Marth
47. *Acesulfame-K*, edited by D. G. Mayer and F. H. Kemper
48. *Alternative Sweeteners: Second Edition, Revised and Expanded*, edited by Lyn O'Brien Nabors and Robert C. Gelardi
49. *Food Extrusion Science and Technology*, edited by Jozef L. Kokini, Chi-Tang Ho, and Mukund V. Karwe

50. *Surimi Technology*, edited by Tyre C. Lanier and Chong M. Lee
51. *Handbook of Food Engineering*, edited by Dennis R. Heldman and Daryl B. Lund
52. *Food Analysis by HPLC*, edited by Leo M. L. Nollet
53. *Fatty Acids in Foods and Their Health Implications*, edited by Ching Kuang Chow
54. *Clostridium botulinum: Ecology and Control in Foods*, edited by Andreas H. W. Hauschild and Karen L. Dodds
55. *Cereals in Breadmaking: A Molecular Colloidal Approach*, Ann-Charlotte Eliasson and Kåre Larsson
56. *Low-Calorie Foods Handbook*, edited by Aaron M. Altschul
57. *Antimicrobials in Foods: Second Edition, Revised and Expanded*, edited by P. Michael Davidson and Alfred Larry Branen
58. *Lactic Acid Bacteria*, edited by Seppo Salminen and Atte von Wright
59. *Rice Science and Technology*, edited by Wayne E. Marshall and James I. Wadsworth
60. *Food Biosensor Analysis*, edited by Gabriele Wagner and George G. Guilbault
61. *Principles of Enzymology for the Food Sciences: Second Edition*, John R. Whitaker
62. *Carbohydrate Polyesters as Fat Substitutes*, edited by Casimir C. Akoh and Barry G. Swanson
63. *Engineering Properties of Foods: Second Edition, Revised and Expanded*, edited by M. A. Rao and S. S. H. Rizvi
64. *Handbook of Brewing*, edited by William A. Hardwick
65. *Analyzing Food for Nutrition Labeling and Hazardous Contaminants*, edited by Ike J. Jeon and William G. Ikins
66. *Ingredient Interactions: Effects on Food Quality*, edited by Anilkumar G. Gaonkar
67. *Food Polysaccharides and Their Applications*, edited by Alistair M. Stephen
68. *Safety of Irradiated Foods: Second Edition, Revised and Expanded*, J. F. Diehl
69. *Nutrition Labeling Handbook*, edited by Ralph Shapiro
70. *Handbook of Fruit Science and Technology: Production, Composition, Storage, and Processing*, edited by D. K. Salunkhe and S. S. Kadam
71. *Food Antioxidants: Technological, Toxicological, and Health Perspectives*, edited by D. L. Madhavi, S. S. Deshpande, and D. K. Salunkhe
72. *Freezing Effects on Food Quality*, edited by Lester E. Jeremiah
73. *Handbook of Indigenous Fermented Foods: Second Edition, Revised and Expanded*, edited by Keith H. Steinkraus
74. *Carbohydrates in Food*, edited by Ann-Charlotte Eliasson
75. *Baked Goods Freshness: Technology, Evaluation, and Inhibition of Staling*, edited by Ronald E. Hebeda and Henry F. Zobel
76. *Food Chemistry: Third Edition*, edited by Owen R. Fennema
77. *Handbook of Food Analysis: Volumes 1 and 2*, edited by Leo M. L. Nollet
78. *Computerized Control Systems in the Food Industry*, edited by Gauri S. Mittal
79. *Techniques for Analyzing Food Aroma*, edited by Ray Marsili
80. *Food Proteins and Their Applications*, edited by Srinivasan Damodaran and Alain Paraf
81. *Food Emulsions: Third Edition, Revised and Expanded*, edited by Stig E. Friberg and Kåre Larsson
82. *Nonthermal Preservation of Foods*, Gustavo V. Barbosa-Cánovas, Usha R. Pothakamury, Enrique Palou, and Barry G. Swanson
83. *Milk and Dairy Product Technology*, Edgar Spreer
84. *Applied Dairy Microbiology*, edited by Elmer H. Marth and James L. Steele
85. *Lactic Acid Bacteria: Microbiology and Functional Aspects, Second Edition, Revised and Expanded*, edited by Seppo Salminen and Atte von Wright

86. Handbook of Vegetable Science and Technology: Production, Composition, Storage, and Processing, *edited by D. K. Salunkhe and S. S. Kadam*
87. Polysaccharide Association Structures in Food, *edited by Reginald H. Walter*
88. Food Lipids: Chemistry, Nutrition, and Biotechnology, *edited by Casimir C. Akoh and David B. Min*
89. Spice Science and Technology, *Kenji Hirasa and Mitsuo Takemasa*
90. Dairy Technology: Principles of Milk Properties and Processes, *P. Walstra, T. J. Geurts, A. Noomen, A. Jellema, and M. A. J. S. van Boekel*
91. Coloring of Food, Drugs, and Cosmetics, *Gisbert Otterstätter*
92. *Listeria*, Listeriosis, and Food Safety: Second Edition, Revised and Expanded, *edited by Elliot T. Ryser and Elmer H. Marth*
93. Complex Carbohydrates in Foods, *edited by Susan Sungsoo Cho, Leon Prosky, and Mark Dreher*
94. Handbook of Food Preservation, *edited by M. Shafiur Rahman*
95. International Food Safety Handbook: Science, International Regulation, and Control, *edited by Kees van der Heijden, Maged Younes, Lawrence Fishbein, and Sanford Miller*
96. Fatty Acids in Foods and Their Health Implications: Second Edition, Revised and Expanded, *edited by Ching Kuang Chow*
97. Seafood Enzymes: Utilization and Influence on Postharvest Seafood Quality, *edited by Norman F. Haard and Benjamin K. Simpson*
98. Safe Handling of Foods, *edited by Jeffrey M. Farber and Ewen C. D. Todd*
99. Handbook of Cereal Science and Technology: Second Edition, Revised and Expanded, *edited by Karel Kulp and Joseph G. Ponte, Jr.*
100. Food Analysis by HPLC: Second Edition, Revised and Expanded, *edited by Leo M. L. Nollet*
101. Surimi and Surimi Seafood, *edited by Jae W. Park*
102. Drug Residues in Foods: Pharmacology, Food Safety, and Analysis, *Nickos A. Botsoglou and Dimitrios J. Fletouris*
103. Seafood and Freshwater Toxins: Pharmacology, Physiology, and Detection, *edited by Luis M. Botana*
104. Handbook of Nutrition and Diet, *Babasaheb B. Desai*
105. Nondestructive Food Evaluation: Techniques to Analyze Properties and Quality, *edited by Sundaram Gunasekaran*
106. Green Tea: Health Benefits and Applications, *Yukihiko Hara*
107. Food Processing Operations Modeling: Design and Analysis, *edited by Joseph Irudayaraj*
108. Wine Microbiology: Science and Technology, *Claudio Delfini and Joseph V. Formica*
109. Handbook of Microwave Technology for Food Applications, *edited by Ashim K. Datta and Ramaswamy C. Anantheswaran*
110. Applied Dairy Microbiology: Second Edition, Revised and Expanded, *edited by Elmer H. Marth and James L. Steele*
111. Transport Properties of Foods, *George D. Saravacos and Zacharias B. Maroulis*
112. Alternative Sweeteners: Third Edition, Revised and Expanded, *edited by Lyn O'Brien Nabors*
113. Handbook of Dietary Fiber, *edited by Susan Sungsoo Cho and Mark L. Dreher*
114. Control of Foodborne Microorganisms, *edited by Vijay K. Juneja and John N. Sofos*
115. Flavor, Fragrance, and Odor Analysis, *edited by Ray Marsili*
116. Food Additives: Second Edition, Revised and Expanded, *edited by A. Larry Branen, P. Michael Davidson, Seppo Salminen, and John H. Thorngate, III*
117. Food Lipids: Chemistry, Nutrition, and Biotechnology: Second Edition, Revised and Expanded, *edited by Casimir C. Akoh and David B. Min*

118. Food Protein Analysis: Quantitative Effects on Processing, *R. K. Owusu-Apenten*
119. Handbook of Food Toxicology, *S. S. Deshpande*
120. Food Plant Sanitation, edited by *Y. H. Hui, Bernard L. Bruinsma, J. Richard Gorham, Wai-Kit Nip, Phillip S. Tong, and Phil Ventresca*
121. Physical Chemistry of Foods, *Pieter Walstra*
122. Handbook of Food Enzymology, edited by *John R. Whitaker, Alphons G. J. Voragen, and Dominic W. S. Wong*
123. Postharvest Physiology and Pathology of Vegetables: Second Edition, Revised and Expanded, edited by *Jerry A. Bartz and Jeffrey K. Brecht*

Additional Volumes in Preparation

Characterization of Cereals and Flours: Properties, Analysis, and Applications, edited by *Gönül Kaletunç and Kenneth J. Breslauer*

International Handbook of Foodborne Pathogens, edited by *Marianne D. Miliotis and Jeffrey W. Bier*

Extraction Optimization in Food Engineering, edited by *Constantina Tzia and George Liadakis*

Handbook of Dough Fermentations, edited by *Karel Kulp and Klaus Lorenz*

Preface to the Second Edition

Postharvest Physiology of Vegetables is extremely useful to everyone concerned with the production and marketing of fresh vegetables. It presents the physiology and associated pathology of fresh vegetables under a single cover. Teachers, students, and researchers, as well as the vegetable industry, can read about the scientific principles that govern the postharvest life of fresh vegetables. The first edition's editor (J. Weichmann) urged his contributors to concentrate on the postharvest physiology of the various plant organs because he sensed the need for a comprehensive discussion of the physiological factors that influence the postharvest life of fresh vegetables. There was no other book quite like the one Weichmann had in mind. He recognized that physiology, not technology, dictates how crops must be handled to maintain optimal quality with minimal waste. Recognizing similarities and differences between various crop physiologies is essential to successful marketing strategies.

Weichmann wrote in the Preface to the first edition that he was motivated by the absence of a book on the "basic postharvest physiology in the botanical sense." Except for *Postharvest Physiology of Vegetables*, this remains largely true today. Books about the postharvest world of crops deal mostly with fruits, toxins in stored grains, and storage technology. Therefore, the second edition is dedicated to those who labor with harvested vegetables, particularly with their physiology or microbiology.

Now, more than 10 years after the first edition of *Postharvest Physiology of Vegetables* was published, it seems appropriate to revisit the postharvest world of vegetables to find what's new, what's still useful, and how the new and still useful can be meshed together to reduce wastage, improve quality, and, most importantly, provide products desired by consumers. In the past decade, consumers have found that a diet rich in fresh fruits and vegetables is healthful and fulfilling, as well as one of the best guarantees against health problems ranging from obesity to cancer. Modern markets have strived to provide consumers with an abundance of different fresh fruits and vegetables. Produce sections

of supermarkets are usually located near the store entrance to convince customers that the market is clean, progressive, and, in general, a nice place to shop. New ways of marketing fresh produce are being devised, including ready-to-eat fruit and vegetable salads, fruit sections, vegetable sticks, and stir-fry vegetables. The new paradigm in produce marketing, which includes providing convenience, a bright, fresh appearance, desired texture, freedom from undesirable microorganisms, and homegrown flavor, has created new challenges for the postharvest practitioner.

Advances in plant physiology, biochemistry, and molecular biology have had great effects on our knowledge and understanding of postharvest physiology. For example, new evidence on the role of ethylene and other plant hormones in various tissue and cellular processes is presented on a seemingly daily basis. The importance of membrane phenomena and membrane compositional changes in the response of plant organs to postharvest stresses is more recognized now than ever. Similarly, there is a greater appreciation for the influence of preharvest environmental and cultural factors on postharvest behavior. Information regarding the mechanisms of atmosphere modification in maintaining plant tissue integrity is transforming what was once strictly an empirical field of study. The growth in popularity of fresh-cut products has focused new attention on wound responses, an understanding of which is critical to the development of handling procedures for these items.

Since the world of vegetables postharvest has changed markedly in recent years, we felt that to be useful the book had to be expanded. As a consequence, sections and chapters were added or reorganized. The title of the book was changed to reflect the coverage of microbial ecosystems on vegetables. Unfortunately, certain topics such as biotechnology and food safety are so dynamic that it is impossible to stay abreast of the latest findings. We ask our readers to be patient with such apparent lapses, for they are out of our control. We feel that the new organization presents a complete treatment of postharvest vegetables.

Chapter topics are grouped into six parts: basic postharvest physiology, factors affecting postharvest physiology, product quality changes during handling and storage, technologies to improve postharvest quality, biotic and abiotic factors involved with spoilage, and storage characteristics of different categories of vegetables. An introductory chapter contains a brief history of the changes in the postharvest world of vegetables over the past decade. It is clear that technological advances have been made possible only because of knowledge about the postharvest physiology of the raw and fresh-cut products.

Part I, "Basic Postharvest Physiology of Vegetables," contains updated reviews of the principles involved with the harvest and storage of fresh vegetables. Part II, "Factors Affecting Postharvest Physiology," includes two new chapters: Chapter 6, on preharvest factors such as calcium nutrition and control of irrigation, which affect the postharvest life of vegetables, and Chapter 7, which covers wound healing, nonspecific respiration increase, as well as the effect of injuries on the physiology of the crop. In addition, three chapters from the previous edition on atmosphere modifications as postharvest treatments have been combined into one to provide a more coherent treatment of the subject.

Part III, "Product Quality Changes During Handling and Storage," has been modified. We have deleted chapters on amino acids and minerals and separated the previous sensory quality chapter into three chapters on color, texture, and flavor and aroma, reflecting the recognition of the physiological basis of sensory aspects in postharvest physiology. Part IV, "Technologies To Improve Postharvest Quality," is entirely new, con-

taining discussions of the physiological foundations of successful technologies in the areas of harvest and handling, chemical treatments, and biotechnology.

Part V, "Biotic and Abiotic Factors Involved with Spoilage," is a revision of the previous edition's part on postharvest diseases and injuries. Modifications include Chapter 19, "Temperature Extremes," which replaces chapters on chilling and freezing injury and frost damage and adds a discussion of high-temperature injury that was not in the previous edition. The chapter on host-parasite relations now includes recent findings on changes in host susceptibility to postharvest pathogens. The chapter on bacteria contains recent information about the survival and growth of human pathogens on fresh vegetables. Two new chapters in this part include one devoted to the control of spoilage using "biocontrol" methods and a separate treatment of the use of sanitation to control spoilage and other hazardous organisms—including a discussion of HACCP as it applies to fresh product packinghouses.

The last part, "Storage Characteristics of Different Categories of Vegetables," contains modifications to the "Postharvest Physiology of Certain Vegetables" part of the first edition. We have categorized vegetables by type of tissue or organ so that their physiology can be discussed on the basis of similarities within a category. Additionally, fresh-cut vegetables are covered under a separate chapter because of the complex nature of preventing the consequences of wound physiology.

Our chapter authors were selected carefully and represent a range of disciplines, including postharvest researchers and teachers from horticulture, plant pathology, microbiology, food science, and engineering. This is fitting because the challenges and problems ahead are not likely to be restricted to any one discipline. Multidisciplinary approaches will become the normal way to solve intransigent postharvest problems in the years to come. We asked the contributors to focus first on the basic principles of postharvest physiology and pathology related to their topic, and then to expand where appropriate to illustrate how those principles relate to the postharvest characteristics and behavior of vegetables. We also asked them to cover the technologies that have been developed for maintaining vegetable quality after harvest. We feel that they have succeeded admirably in that regard. We express gratitude to them for agreeing to contribute to this volume, devoting time and energy to the cause, turning out excellent analyses of their topic, and remaining patient with us throughout the process.

It is the express purpose of this book to review various components of the postharvest world of vegetables. We hope that students of all ages will be stimulated into devising ways for better preservation of vegetable quality, more vegetable products (particularly fresh-cut vegetables), safer products, and a wider array of vegetables in the marketplace—all leading to healthier diets, less strain on the environment, and a happier society.

Jerry A. Bartz
Jeffrey K. Brecht

Preface to the First Edition

According to a study of the Food and Agricultural Organization of the United Nations, large losses of vegetables occur yearly during the postharvest period. These losses are high not only in less developed countries, but also in very well-developed ones where modern technologies are available.

A number of books have addressed postharvest technologies, but the physiology of plant foods is usually covered on a small scale, and sometimes not at all. This in spite of the fact that the basis of all technological measures is the reaction of the plant, which means the physiology of the plant.

Postharvest technology has to be based on postharvest physiology. For a long time I have lamented that no book existed dealing with basic postharvest physiology in the botanical sense. This book is dedicated to all those working with vegetable crops who want to increase their knowledge as well as look for the underlying principles: to advisers and managers, to students as well as teachers, in practice or at universities.

It is impossible for one person to summarize all the knowledge of postharvest physiology, because research in this topic is divided into numerous disciplines. So a number of well-known scientists from all over the world were asked to focus on certain areas of postharvest physiology, providing information that is comprehensive, complete, and incorporates the latest results. Each chapter is complete in itself, but cross-references have been made to avoid repetition.

The editor wishes to express his appreciation to all of the authors, who accepted a task of several years' duration. My sincere thanks go to the publisher for initiating this project, as well as for their interest and cooperation during the preparation of this volume.

It is our mutual wish that this book will help to avoid or at least reduce quality losses during the postharvest period. The book shall also help reduce crop losses—and thereby fight against hunger worldwide. Hunger is caused by the human, and the human must fight against it.

J. Weichmann

Contributors

Alexandros Aggelis Institute of Viticulture Vegetable Crops and Floriculture, National Agricultural Research Foundation, Heraklion, Crete, Greece

Elizabeth A. Baldwin Citrus and Subtropical Products Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Winter Haven, Florida, U.S.A.

M. Margaret Barth Redi-Cut Foods, Inc., Franklin Park, Illinois, U.S.A.

Jerry A. Bartz Plant Pathology Department, University of Florida, Gainesville, Florida, U.S.A.

Shimshon Ben-Yehoshua Department of Postharvest Science of Fresh Produce, Agricultural Research Organization—The Volcani Center, Bet Dagan, Israel

Mondher Bouzayen Ecole Nationale Supérieure Agronomique de Toulouse and Institut National de la Recherche Agronomique, Toulouse, France

Jeffrey K. Brecht Horticultural Sciences Department, University of Florida, Gainesville, Florida, U.S.A.

William S. Conway Produce Quality and Safety Laboratory, Beltsville Agricultural Research Center, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Maryland, U.S.A.

Jean Pierre Emond Department of Soils and Agrifood Engineering, Laval University, Quebec City, Quebec, Canada

Robert Golaszewski Food Science and Human Nutrition Department, University of Florida, Gainesville, Florida, U.S.A.

Wojciech J. Janisiewicz Appalachian Fruit Research Station, Agricultural Research Service, U.S. Department of Agriculture, Kearneysville, West Virginia, U.S.A.

Adel A. Kader Department of Pomology, University of California, Davis, Davis, California, U.S.A.

Angelos K. Kanellis Department of Pharmaceutical Sciences, Aristotle University of Thessaloniki, Thessaloniki, Greece

Graeme King Ministry of Agriculture and Forestry, Wellington, New Zealand

Lise Korsten Department of Microbiology and Plant Pathology, University of Pretoria, Pretoria, South Africa

Alain Latché Ecole Nationale Supérieure Agronomique de Toulouse and Institut National de la Recherche Agronomique, Toulouse, France

Pamela M. Ludford* Department of Fruit and Vegetable Science, Cornell University, Ithaca, New York, U.S.A.

Niels Maness Department of Horticulture and Landscape Architecture, Oklahoma State University, Stillwater, Oklahoma, U.S.A.

A. Raymond Miller Department of Horticulture and Crop Science, Ohio Agricultural Research and Development Center, The Ohio State University, Wooster, Ohio, U.S.A.

Majeed Mohammed Department of Food Production, Faculty of Agriculture and Natural Sciences, The University of the West Indies, St. Augustine, Trinidad

Maria Cecília do Nascimento Nunes Department of Soils and Agrifood Engineering, Laval University, Quebec City, Quebec, Canada

Erin M. O'Donoghue New Zealand Institute for Crop & Food Research Ltd., Palmerston North, New Zealand

Jean-Claude Pech Ecole Nationale Supérieure Agronomique de Toulouse and Institut National de la Recherche Agronomique, Toulouse, France

Penelope Perkins-Veazie South-Central Agricultural Research Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Lane, Oklahoma, U.S.A.

* Deceased.

Dov Prusky Department of Postharvest Science of Fresh Produce, Agricultural Research Organization—The Volcani Center, Bet Dagan, Israel

Victor Rodov Department of Postharvest Science of Fresh Produce, Agricultural Research Organization—The Volcani Center, Bet Dagan, Israel

Mikal E. Saltveit Louis K. Mann Laboratory, Department of Vegetable Crops, University of California, Davis, Davis, California, U.S.A.

Carl E. Sams Department of Plant and Soil Sciences, The University of Tennessee, Knoxville, Tennessee, U.S.A.

Maite Sanmartin Institute of Viticulture, Vegetable Crops, and Floriculture, National Agricultural Research Foundation, and Institute of Molecular Biology and Biotechnology, Foundation for Research and Technology—Hellas, Heraklion, Crete, Greece

Robert L. Shewfelt Department of Food Science and Technology, The University of Georgia, Athens, Georgia, U.S.A.

Charles A. Sims Food Science and Human Nutrition Department, University of Florida, Gainesville, Florida, U.S.A.

Andrew C. Smith Institute of Food Research, Colney, Norwich, U.K.

Mark L. Tamplin* Department of Family, Youth, and Community Sciences, University of Florida, Gainesville, Florida, U.S.A.

Keith W. Waldron Institute of Food Research, Colney, Norwich, U.K.

Chien Yi Wang Produce Quality and Safety Laboratory, Beltsville Agricultural Research Center, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Maryland, U.S.A.

Fritz C. Wehner Department of Microbiology and Plant Pathology, University of Pretoria, Pretoria, South Africa

Cheng-I Wei Nutrition and Food Science Department, Auburn University, Auburn, Alabama, U.S.A.

Bruce D. Whitaker Produce Quality and Safety Laboratory, Plant Sciences Institute, Beltsville Agricultural Research Center, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Maryland, U.S.A.

Hong Zhuang Redi-Cut Foods, Inc., Franklin Park, Illinois, U.S.A.

* *Current affiliation:* Eastern Regional Research Center, Agricultural Research Service, U.S. Department of Agriculture, Wyndmoor, Pennsylvania, U.S.A.

Postharvest Physiology and Pathology of Vegetables