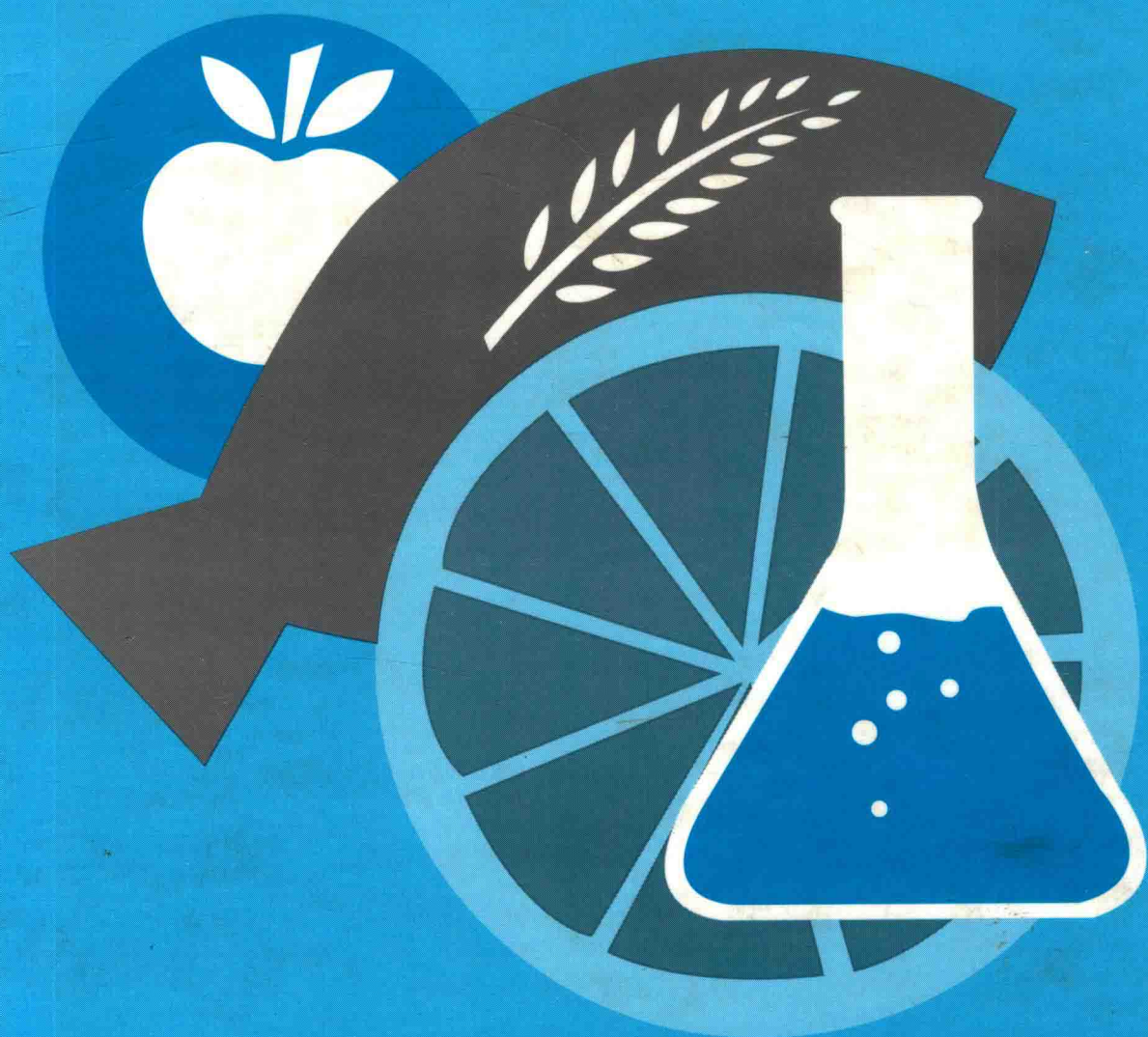


ADVANCES IN FOOD ENGINEERING

Edited by R. Paul Singh
M. A. Wirakartakusumah





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Edited by

R. Paul Singh

Professor of Food Engineering
Department of Agricultural
Engineering
University of California
Davis, California

M. A. Wirakartakusumah

Department of Food Science
and Human Nutrition
Institute Pertanian Bogor
Bogor, Indonesia



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DEDICATION

This book is dedicated to our fellow colleagues and researchers, particularly, Dr. Dennis R. Heldman and Dr. Daryl B. Lund, who have constantly inspired us with their ingenuity, resourcefulness and scholarship.

Food Engineering

R. Paul Singh, Series Co-Editor
University of California, Davis

Dennis R. Heldman, Series Co-Editor
Weinberg Consulting Group, Inc.
Washington, D.C.

Forthcoming Titles

Transport Phenomena of Foods and Biological Materials, V.Gekas

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SERIES PREFACE

The overall objectives of the CRC Series in Food Engineering are to stimulate curiosity, promote dialogue, and encourage research and publication of current information in the area of food engineering. Food engineering is an evolving discipline and involves the application of engineering concepts and principles to all aspects of food processing and operations. Although many of these applications involve the direct application of traditional engineering disciplines, the focus of food engineering is on the unique requirements of engineering as they occur throughout the food chain. Most often, these unique applications involve the special sensitivities of the food ingredients and final product as well as special requirements for sanitation. In summary, the scope of the CRC Series in Food Engineering will incorporate information on engineering applications in any aspect of the food industry.

The first volume of this series, *Advances in Food Engineering*, contains proceedings of a workshop held in Jakarta, Indonesia, September 2-6, 1991. It includes original contributions from food engineers on topics of current interest.

R. Paul Singh, Ph.D.

Series Co-Editor
Professor of Food Engineering
Department of Agricultural Engineering
University of California,
Davis, California

Dennis R. Heldman, Ph.D.

Series Co-Editor
Weinberg Consulting Group, Inc.
2828 Pennsylvania Avenue, NW,
Suite 305, Washington, D.C.

PREFACE

The worldwide evolution of the food engineering discipline continues at a rapid pace. The food industry in the industrialized countries has begun to recognize the important role of food engineers at various levels of its operations. This relatively new branch of engineering is now being considered by many as an important element in industrial research and operations. Today's food engineer, educated with a unique blend of engineering and biological sciences, is providing an important and previously missing link between food scientists and engineers (trained in traditional fields). In the developing countries, there is an increased recognition of the need to devote more attention to problems facing the postharvest food chain. While there have been dramatic increases in the production of several agricultural crops, the average consumer in most countries has been unable to reap the increased benefits. Often large quantities of food perish before reaching the market. There is an urgent need to design and develop improved postharvest systems in developing countries. There are a multitude of opportunities to apply food engineering principles to improve these systems. With these concerns in mind, an international workshop was planned to review recent advances in food engineering and explore their applications to the needs of a developing country.

The international workshop on "Role of Food Engineering Research in the Development of Indonesian Food Industry" was held in Jakarta, Indonesia, September 2-6, 1991. The overall objectives of this workshop were to review some of the key advances in food engineering during the last five years, and develop strategies that would be of assistance to food engineers in the developing countries in finding solutions to problems encountered in postharvest handling and processing of foods.

Workshop participants were invited from North America, Europe, Australia/New Zealand and Asia. The format of this workshop was similar to an Advanced Research Workshop on "Food Properties and Computer-Aided Engineering of Food Processing Systems" held in Porto, Portugal under the auspices of NATO in 1988. Specifically, the participants reviewed the latest advances in their fields of expertise, followed by significant allocation of time for discussion. This mechanism provided the Indonesian participants with an opportunity to further their knowledge on topics of interest. In addition, there were a number of talks given by Indonesian participants from food industries and government organizations. The follow-up discussions were aimed at identifying issues that should be addressed in considering food engineering/processing solutions.

This book includes all original contributions of the workshop participants. All recorded discussions are also included with individual papers. A review of issues relevant to technology transfer as identified by the workshop participants is appended. While these issues were developed within the Indonesian context, many of these are universally applicable.

A number of agencies provided assistance that made this workshop possible. In particular, appreciation is extended to the World Bank XVII Project (MUCIA), Ministry of Industry, The Agency of Assessment and Application of Technology Ministry of Research, Ministry of Agriculture, Ministry of Education and Culture, and Ministry of Trade. A number of Indonesian Food Industries supported this conference including PT. Mantrust, PT. Pulau Sambu, PT. Tamara Overseas Corporation, PT. Mitra Sembada Informatika/Apple Center, PT. Sanmaru Food Manufacturing, PT. Ultra Jaya, PT. Unilever Indonesia, PT. Sayang Heulang, PT. Gudang Garam, PT. Australia Indonesian Milk Industries.

R. PAUL SINGH

A. WIRAKARTAKUSUMAH

THE EDITORS

R. Paul Singh, Ph.D., is Professor of Food Engineering, Department of Agricultural Engineering, Department of Food Science and Technology, University of California, Davis, California.

Dr. Singh graduated in 1970 from Punjab Agricultural University, Ludhiana, India, with a degree in Agricultural Engineering; he obtained an M.S. degree from University of Wisconsin, Madison, and a Ph.D. degree from Michigan State University in 1974. Following a year of teaching at Michigan State University, he moved to University of California, Davis in 1975 as an Assistant Professor of Food Engineering. He was promoted to Associate Professor in 1979, and again to Professor in 1983.

Dr. Singh is a member of the Institute of Food Technologists, American Society of Agricultural Engineers, Council for Agricultural Science and Technology and Sigma Xi. He received the First Place Paper Award, American Society of Agricultural Engineers in 1982; Samuel Cate Prescott Award for Research, Institute of Food Technologists, 1982; A.W. Farrall Young Educator Award, American Society of Agricultural Engineers, 1986; NATO Senior Guest Lecturer, 1987; IFT International Award, Institute of Food Technologists, 1988; and Distinguished Alumnus Award, Punjab Agricultural University, 1989.

Dr. Singh has authored and co-authored 4 books and over 140 technical papers. He is a co-editor of the *Journal of Food Process Engineering*. His current research interests are in transport phenomena in foods as influenced by structural changes during processing. His research is supported by grants from federal and state agencies and food industries from U.S., Japan and European Countries.

M. Aman Wirakartakusumah, Ph.D., is Dean and Senior Lecturer, Faculty of Agricultural Technology, and Director, Food and Nutrition Inter University Center, Institut Pertanian Bogor (IPB), Bogor, Indonesia. He is also the National Coordinator for FAO Food Control Training Program in Asia.

Dr. Wirakartakusumah graduated in 1972 from IPB, Indonesia. He received an M.S. degree in 1977, followed with a Ph.D. degree in 1981 in Food Science from University of Wisconsin, Madison. Since 1971, he has been working as a member of the Faculty of Agricultural Technology, IPB, Bogor, Indonesia. He has participated in a number of training programs offered by international institutions such as, University of Tokyo, Japan; National Food Research Institute, Tsukuba, Japan; and Flour, Milling and Baking Research Association, Chorleywood, UK.

Dr. Wirakartakusumah is a member of the Institute of Food Technologists, member of the Indonesian Association of Food and Nutrition, and the Indonesian Association of Food Technologists (past Vice-President). He was the recipient of the International Student Award of IFT-SOS 1970.

Dr. Wirakartakusumah has received research grants from national and private industries in Indonesia. His current research interests are in the application of heat and mass transfer in food processing. He has been invited as speaker at a number of international meetings and conferences.

LIST OF CONTRIBUTORS

- Akinaga, T.** College of Agriculture, University of the Ryukyus, Senbaru 1, Nishihara-cho, Okinawa 903-01, Japan.
- Bartsch, J. A.** Department of Agricultural and Biological Engineering, Cornell University, Riley-Robb Hall, Ithaca, New York 14853, USA.
- Brady, J. W., Jr.** Department of Food Science, Cornell University, 108 Stocking Hall, Ithaca, NY 14853, USA.
- Bruin, S.** Unilever Research Laboratory, Vlaardingen, The Netherlands.
- Cheryan, M.** Department of Food Science, University of Illinois, 1304 West Pennsylvania Avenue, Urbana, Illinois 61801, USA.
- Cleland, A. C.** Department of Biotechnology, Massey University, Palmerston North, New Zealand.
- DeBaerdemaeker, J.G.** Department of Agricultural Engineering, Katholieke Universiteit Leuven, Kardinaal Mercierlaan 92, B-3001, Leuven, Belgium.
- Edwards, R. A.** Department of Food Science and Technology, University of New South Wales, POB 1 Kensington, NSW 2033, Australia.
- Hayakawa, K.** Food Science Department, Rutgers University-Cook College, P.O. Box 231, New Brunswick, New Jersey 08903, USA.
- Heldman, D. R.** Weinberg Consulting Group, Inc., 2828 Pennsylvania Avenue, NW, Suite 305, Washington, D.C. 20007, USA.
- Hendrickx, M.E.** Department of Food Science, Katholieke Universiteit Leuven, Kardinaal Mercierlaan 92, B-3001, Leuven, Belgium.
- Hori, T.** Technical Research Institute, Snow Brand Milk Products Co., Ltd., Minamidai 1-1-2, Kawagoe, Saitama 350, Japan.
- Ishikawa, M.** Food Science and Technology, Tokyo University of Fisheries, 5-7 Konan, Minato-ku, Tokyo 108, Japan.
- Kokini, J. L.** Department of Food Science, Rutgers University, P.O. Box 231, New Brunswick, NJ 08903, USA.
- Krochta, J. M.** Department of Food Science and Technology, University of California-Davis, Davis, California 95616, USA.
- Labuza, T. P.** Department of Food Science, University of Minnesota, St. Paul, Minnesota 55108, USA.
- Lund, D. B.** Department of Food Science, Rutgers University, P.O. Box 231, New Brunswick, New Jersey 08903, USA.

- MacCarthy, D.** Department of Food Engineering, University College Cork, Cork, Ireland.
- McCarthy, M. J.** Food Science and Technology, University of California-Davis, Davis, California 95616, USA.
- Nakamura, K.** Department of Biological and Chemical Engineering, Gunma University, Kiryu, Gunma 376, Japan.
- Nesvadba, P.** Torry Research Station, 135 Abbey Road, Aberdeen, AB9 8DG, Scotland.
- Nihmura, M.** Central Research Laboratories, Ajinomoto General Foods, Inc., Minami-tamagaki-cho 6410, Suzuka-city, Mie-prefecture, Japan.
- Oshita, S.** Laboratory of Bio. Information Engr., Mie University, Kamihama-cho, Tsu-city, Mie prefecture, Japan.
- Poulsen, K. P.** Technical University of Denmark, Block 221 DK 2800, Lyngby, Denmark.
- Purwadaria, H. K.** Department of Agricultural Engineering, Institut Pertanian Bogor, POB 122, Bogor, Indonesia.
- Rao, M. A.** Department of Food Science and Technology, Cornell University, Geneva, New York 14456, USA.
- Reid, D. S.** Department of Food Science and Technology, University of California-Davis, Davis, California 95616, USA.
- Robertson, G. L.** Department of Biotechnology, Massey University, Palmerston North, New Zealand.
- Sagara, Y.** Department of Agricultural Engineering, The University of Tokyo, Yayoi 1-1-1, Bunkyo-ku Tokyo 113, Japan.
- Sastry, S. K.** Department of Agricultural Engineering, Ohio State University, 590 Woody Hayes Drive, Columbus, Ohio 43210, USA.
- Singh, R. P.** Department of Agricultural Engineering, University of California-Davis, Davis, California 95616, USA.
- Smith, A. C.** Norwich Laboratory, AFRC Institute of Food Research, Colney, Norwich, NR4 7UA, United Kingdom.
- Soekarto, S. T.** Institut Pertanian Bogor, POB 122, Bogor, Indonesia.
- Steffe, J.** Department of Agricultural Engineering, Michigan State University, East Lansing, Michigan 48824, USA.
- Suzuki, K.** Hiroshima University, 1-4-4 Kagamiyama, Higashi-Hiroshima 724, Japan.

- Teixeira, A. A.** Agricultural Engineering Department, University of Florida, Frazier Rogers Hall, Gainesville, Florida 32611, USA.
- Thorpe, G. R.** Division of Entomology, CSIRO, P.O. Box 26-Highett, Victoria, Australia 3190.
- Tobback, P.** Department of Food Science, Katholieke Universiteit Leuven, Kardinaal Mercierlaan 92, B-3001, Leuven, Belgium.
- Tung, M.A.** Food Science and Technology, Technical University of Nova Scotia, POB 1000, Halifax NS, B3J 2X4, Canada.
- Watanabe, H.** Food Science and Technology Department, Tokyo University of Fisheries, Konan 4-5-7, Minato-ku, Tokyo 108, Japan.
- Weisser, H.** Lehrstuhl Für Brauereianlagen Und Lebensmittelverpackungstechnik, D-8050 Freising, Weihenstephan, Germany.
- Wirakartakusumah, M. A.** Department of Food Science and Human Nutrition, Institute Pertanian Bogor, POB 122, Bogor, Indonesia.
- Yano, T.** Department of Agricultural Chemistry, University of Tokyo, 1-1-1 Yayoi, Bunkyo-ku, Tokyo, 113 Japan.

TABLE OF CONTENTS

Preface

List of Contributors

Part I. Water Relations of Foods and Their Role in Dehydration Processes

Chapter 1	
Water Relations of Foods, A Key to Product Stability	3
D. S. Reid	
Chapter 2	
Flavor Retention in Dehydration Processes	15
S. Bruin	
Chapter 3	
Application of NMR-Spectroscopy in Studying Self-Diffusion of Water in Cellulose Packaging Materials	33
H. Weisser and F. Liebenspacher	
Chapter 4	
Some Advances in the Theory of Mass Transfer Processes in Food Engineering	49
G. R. Thorpe	
Chapter 5	
Osmotic Dehydration of Food by Semipermeable Membrane Coating	73
M. Ishikawa and H. Nara	
Chapter 6	
Moisture Diffusion in Soybean Seed Measured by NMR	79
H. Watanabe M. Yoshida	

Part II. Measurement of Food Properties and Their Role in Optimizing Food Processing Operations

Chapter 7	
Structure/Property Measurements Using Magnetic Resonance Spectroscopy and Imaging	87
M. J. McCarthy, J.E. Maneval and R.L. Powell	
Chapter 8	
Measurement of Thermal Properties and Prediction of Transient Temperatures in Foodstuffs: Application to Mail-Order Smoked Salmon	99
P. Nesvadba	

Chapter 9	
Automatic Measurement System for Transport Properties of Food Samples Undergoing Sublimation Dehydration	111
Y. Sagara	
Chapter 10	
Thermodynamical Estimation of the Specific Heat of Rice	125
S. Oshita	
Part III. Advances in Heat and Mass Transfer and Their Application in Improving Food Processing Operations	
Chapter 11	
Advances in Ohmic Heating for Sterilization of Liquid-Particle Mixtures	139
S. K. Sastry	
Chapter 12	
Microwave Heat Transfer in Food	149
C. W. Tong, S. A. Sheen, Y. F. Fu, D. L. Goedeken and D. B. Lund	
Chapter 13	
Membrane Technology in Food and Bioprocessing	165
M. Cheryan	
Chapter 14	
Dynamic Modelling of Heat Transfer for Improvement in Process Design-Case Studies Involving Refrigeration	181
A. C. Cleland	
Chapter 15	
Probabilistic Modeling and Sensitivity Analysis in Heat Transfer Computations	193
B. M. Nicolai and J. G. DeBaerdemaeker	
Chapter 16	
Heat Transfer Efficacy of Overpressure Media in Rotational Thermal Processes for Shelf Stable Foods in Plastic Packages	207
M. A. Tung and I. J. Britt	
Chapter 17	
Optimization of Heat Transfer in Thermal Processing of Conduction Heated Foods	221
M. E. Hendrickx, C. L. Silva, F. A. Oliveira and P. Tobback	
Chapter 18	
Measurement of Oil/Water Interface in Foods During Frying	237
B. E. Farkas, R. P. Singh and M.J. McCarthy	

Chapter 19	
Deep Frying Expansion of Indonesian Sago Chips (Krupuk) as Affected by the State of Its Bound Water	247
S.T. Soekarto, D. Muliawan and Rini Zulviani	
Chapter 20	
Novel Utilization of Supercritical Carbon Dioxide for Enzymatic Reaction and Food Processing	257
K. Nakamura, T. Hoshino	
Chapter 21	
Destruction of Mold Spores, Mycotoxins and Insects in Grain by HTST (High Temperature Short Time) Treatment	263
C. K. Wilkins, C. Tørngren, O. Filtenborg and K.P. Poulsen	
 Part IV: Innovations in Equipment Design and Plant Operations	
Chapter 22	
Controlled Atmosphere Storage Systems for Fruits and Vegetables	275
J. A. Bartsch	
Chapter 23	
Innovations in Conduction-Heating Models for On-Line Retort Control of Canned Foods with Any J-Value	293
A. A. Teixeira, G. S. Tucker, M. O. Balaban and J. Bichier	
Chapter 24	
Innovative Concepts in Equipment Design for Aseptic Processing	309
D. R. Heldman	
Chapter 25	
Food Engineering Innovation and Reinvention: An Example of Industrial Application	321
T. Hori	
Chapter 26	
Continuous Monitoring of Refrigeration Plant Efficiency	333
D. MacCarthy and C. Coughlan	
Chapter 27	
Quality Design and Plant Operation in Food Processing	341
M. Nihmura and R. Taniguchi	

Part V. Structural and Rheological Considerations in Food Processing

Chapter 28 The Use of Computer Modeling to Study the Physical Properties of Food Molecules J. W. Brady, Jr.	349
Chapter 29 Yield Stress: Phenomena and Measurement J. F. Steffe	363
Chapter 30 Rheology of Cowpea Slurries and of Sol-Gel Transition P. E. Okechukwu and M. A. Rao	377
Chapter 31 The Structure and Rheology of Processed Starch Materials A. C. Smith	393
Chapter 32 Modelling and Control of the Product Structure of Food Emulsions L. H. Wesdorp, H. J. Human and S. Bruin	409
Chapter 33 Influence of Constituent Concentration and Particle Diameter on Rheological Properties of Food Emulsions K. Suzuki, K. Matsuoka and K. Uno	429
Chapter 34 Measurement and Simulation of Shear and Shear Free (Extensional) Flows in Food Rheology J. L. Kokini	439
Chapter 35 Strain-Stress Formation in Food Undergoing a Heat and Moisture Transfer Process K. Hayakawa, N. Sakai and Y. Itaya	463
Chapter 36 Measurement of Fluid Viscosity by a Hot-Wire Method and Its Application to the Cheese Industry T. Hori	475
Chapter 37 Among Seven Unknown Elastic Parameters of Porous Foods, Five Can Be Calculated If Two Are Given T. Yano	491
Part VI: Reaction Kinetics in Food Processing, Packaging and Storage	
Chapter 38 A simple Method for the Routine Evaluation of Polymer Film Barrier Properties and a Basis for Novel Time-Temperature Indicators G. L. Robertson	503

Chapter 39	
Control of Mass Transfer in Foods with Edible-Coatings and Films	517
J. M. Krochta	
Chapter 40	
Criteria for Experimental Kinetic Design and Prediction of Food Shelf Life	539
L. N. Bell, B. Fu and T. P. Labuza	
Chapter 41	
The Use of Immobilized Enzymes as Time-Temperature Indicator System in Thermal Processing	561
P. Tobback, M. E. Hendrickx, Z. Weng, G. J. Maesmans and S. V. DeCordt	
Chapter 42	
Problems in the Air Shipment of Horticultural Products	575
T. Akinaga and Y. Kohda	
PART VII: Food Engineering Research and Development in Indonesia	
Chapter 43	
Food Engineering Research: An Opportunity for Cooperation	591
D. B. Lund	
Chapter 44	
Approaches to Food Drying at the Village and Larger-Scale Levels	599
R. A. Edwards and R. H. Driscoll	
Chapter 45	
Current Research in Water Relation in Foods and Their Role in Food Processes in Indonesia	611
S. T. Soekarto	
Chapter 46	
Current Research in Heat and Mass Transfer and Their Applications in Improving Food Processing Operations in Indonesia	619
H. K. Purwadaria	
Chapter 47	
Current Research in Kinetics of Food Quality Changes During Processing and Storage in Indonesia	629
M. A. Wirakartakusumah, B. Satiawihardja and D. Syah	
Appendix	639
Workshop Discussion	
Index	643

Part I

Water Relations of Foods and Their Role in Dehydration Processes