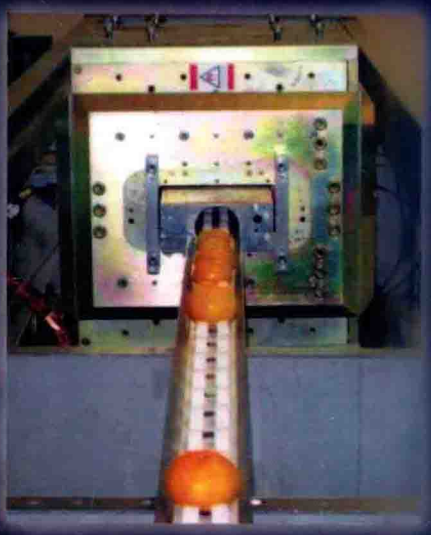
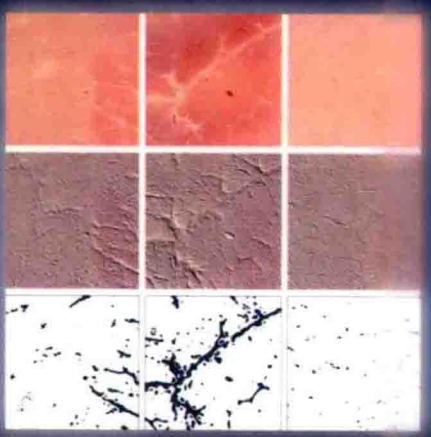
Contemporary Food Engineering Series

Da-Wen Sun, Series Editor

Emerging Technologies for Food Quality and Food Safety Evaluation





Edited by
Yong-Jin Cho
Sukwon Kang

CRC Press
Taylor & Francis Group

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常州大学山书馆
藏书章

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CRC Press
Taylor & Francis Group
Boca Raton London New York

CRC Press is an imprint of the
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CRC Press
Taylor & Francis Group
6000 Broken Sound Parkway NW, Suite 300
Boca Raton, FL 33487-2742

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Printed in the United States of America on acid-free paper
10 9 8 7 6 5 4 3 2 1

International Standard Book Number: 978-1-4398-1524-3 (Hardback)

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Emerging Technologies for Food Quality and Food Safety Evaluation

Contemporary Food Engineering

Series Editor

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Series Preface

Food engineering is the multidisciplinary field of applied physical sciences combined with the knowledge of product properties. Food engineers provide the technological knowledge transfer essential to the cost-effective production and commercialization of food products and services. In particular, food engineers develop and design processes and equipment in order to convert raw agricultural materials and ingredients into safe, convenient, and nutritious consumer food products. However, food engineering topics are continuously undergoing changes to meet diverse consumer demands, and the subject is being rapidly developed to reflect market needs.

In the development of food engineering, one of the many challenges is to employ modern tools and knowledge, such as computational materials science and nanotechnology, to develop new products and processes. Simultaneously, improving quality, safety, and security remains a critical issue in the study of food engineering. New packaging materials and techniques are being developed to provide more protection to foods, and novel preservation technologies are emerging to enhance food security and defense. Additionally, process control and automation regularly appear among the top priorities identified in food engineering. Advanced monitoring and control systems are developed to facilitate automation and flexible food manufacturing. Furthermore, energy savings and minimization of environmental problems continue to be important issues in food engineering, and significant progress is being made in waste management, efficient utilization of energy, and reduction of effluents and emissions in food production.

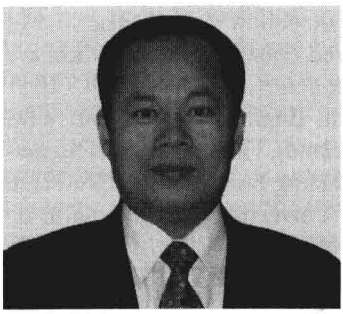
The Contemporary Food Engineering book series, which consists of edited books, attempts to address some of the recent developments in food engineering. Advances in classical unit operations in engineering related to food manufacturing are covered as well as such topics as progress in the transport and storage of liquid and solid foods; heating, chilling, and freezing of foods; mass transfer in foods; chemical and biochemical aspects of food engineering and the use of kinetic analysis; dehydration, thermal processing, nonthermal processing, extrusion, liquid food concentration, membrane processes, and applications of membranes in food processing; shelf-life, electronic indicators in inventory management, and sustainable technologies in food processing; and packaging, cleaning, and sanitation. These books are aimed at professional food scientists, academics researching food engineering problems, and graduate-level students.

The editors of these books are leading engineers and scientists from all parts of the world. All of them were asked to present their books in such a manner as to address the market needs and pinpoint the cutting-edge technologies in food engineering. Furthermore, all contributions are written by internationally renowned experts who have both academic and professional credentials. All authors have attempted to

provide critical, comprehensive, and readily accessible information on the art and science of a relevant topic in each chapter, with reference lists for further information. Therefore, each book can serve as an essential reference source to students and researchers in universities and research institutions.

Da-Wen Sun
Series Editor

Series Editor



Born in southern China, Professor Da-Wen Sun is a world authority in food engineering research and education; he is a member of the Royal Irish Academy, which is the highest academic honor that can be attained by scholars and scientists working in Ireland. His main research activities include cooling, drying, and refrigeration processes and systems; quality and safety of food products; bioprocess simulation and optimization; and computer vision technology. Especially, his innovative studies on vacuum cooling of cooked meats, pizza quality inspection by computer vision, and edible films for shelf-life extension of fruits and vegetables have been widely reported in national and international media. The results of his work have been published in over 500 papers including 200 peer reviewed journal papers. According to Thomson Scientific's *Essential Science Indicator*^{SM} updated as of July 1, 2010 based on data derived over a period of 10 years and 4 months (January 1, 2000 to April 30, 2010) from the ISI Web of Science, a total of 2,554 scientists are among the top 1% of the most frequently cited scientists in the category of Agricultural Sciences, and professor Sun tops the list with his ranking of 31.

Sun received his B.Sc. honors (first class), his M.Sc. in mechanical engineering, and his Ph.D. in chemical engineering in China before working in various universities in Europe. He became the first Chinese national to be permanently employed in an Irish university when he was appointed as college lecturer at the National University of Ireland, Dublin (University College Dublin) in 1995, and was then continuously promoted in the shortest possible time to senior lecturer, associate professor, and full professor. He is currently the professor of food and biosystems engineering and the director of the Food Refrigeration and Computerized Food Technology Research Group at University College Dublin.

Sun has contributed significantly to the field of food engineering as a leading educator in this field. He has trained many Ph.D. students who have made their own contributions to the industry and academia. He has also regularly given lectures on advances in food engineering in international academic institutions and delivered keynote speeches at international conferences. As a recognized authority in food engineering, he has been conferred adjunct/visiting/consulting professorships from 10 top universities in China including Zhejiang University, Shanghai Jiaotong University, Harbin Institute of Technology, China Agricultural University, South China University of Technology, and Jiangnan University. In recognition of his significant contribution to food engineering worldwide and for his outstanding leadership in this field, the International Commission of Agricultural and Biosystems Engineering (CIGR) awarded him the CIGR Merit Award in 2000 and again in 2006. The Institution of Mechanical Engineers (IMechE) based in the United Kingdom

named him Food Engineer of the Year 2004. In 2008, he was awarded the CIGR Recognition Award in honor of his distinguished achievements in the top 1% of agricultural engineering scientists in the world. In 2007, he was presented with the AFST (I) Fellow Award by the Association of Food Scientists and Technologists (India), and in 2010 he was presented with the CIGR Fellow Award. The title of Fellow is the highest honor in CIGR, and is conferred upon individuals who have made sustained, outstanding contributions worldwide.

Sun is a Fellow of the Institution of Agricultural Engineers and a Fellow of Engineers Ireland (the Institution of Engineers of Ireland). He has received numerous awards for teaching and research excellence, including the President's Research Fellowship and the President's Research Award of University College Dublin on two occasions. He is the CIGR Incoming President in 2011–2012, President in 2013–2014, and Past President in 2015–2016, and a member of the CIGR Presidium and CIGR Executive Board. He is also the editor-in-chief of *Food and Bioprocess Technology—An International Journal* (Springer); the former editor of *Journal of Food Engineering* (Elsevier); and an editorial board member for *Journal of Food Engineering* (Elsevier), *Journal of Food Process Engineering* (Blackwell), *Sensing and Instrumentation for Food Quality and Safety* (Springer), and *Czech Journal of Food Sciences*. He is a chartered engineer.

Preface

The evaluation of food quality and safety is one of the key tasks in the manufacturing process of foods and beverages as well as in their R&D. Even though food quality may depend on its hedonic aspect, its quantitative evaluation becomes more important in the food industry and academia. Fortunately, it is possible to definitely evaluate food quality, owing to the advent of some sophisticated systems, including nondestructive testing techniques and emerging technology. The aim of this book is to review and introduce the state-of-the-art technology and systems for quantitative evaluation of food quality, particularly those suitable for definite measurement of it. Also, this book will cover detecting systems for food safety because good foods relate directly to safe foods.

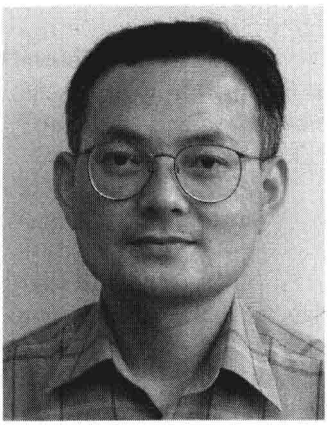
This book has eleven chapters, including an introductory chapter to describe concept and scope of food quality parameters such as color, texture, shape and size, chemical compositions, flavor, safety, and so on. Chapters 2 to 11 deal with individual systems for quality parameters, i.e., instruments for textural and rheological properties, artificial intelligent systems for sensory evaluation, computer vision, near infrared (NIR), nuclear magnetic resonance (NMR) and magnetic resonance imaging (MRI), sonic and ultrasonic systems, multispectral and hyperspectral imaging techniques, electronic noses, biosensors, and nanotechnology in food quality and safety evaluation systems. Each chapter describes the principles related to each system and applications to foods.

Especially, biosensors in Chapter 10 and nanotechnology in Chapter 11 are recognized as new tools for laboratory analysis and *on-site* industrial use. Conventionally speaking, food biosensors are typically used for the biochemical evaluation of food, such as quality analysis and safety monitoring, rather than for the determination of physical properties. Recently, nanotechnology is being applied in enhancement of sensitivity and detection limit in measurement systems for food quality and safety.

It is hoped that this book will encourage those already working in the food industry and scientists in universities and research institutes, and help clarity the needs of the food industry and stimulate new ideas, either for importing technologies from other disciplines or for the development of new approaches to food quality evaluation.

Yong-Jin Cho

The Editors



Yong-Jin Cho, born in Korea, received his B.S., M.S., and Ph.D. degrees from Seoul National University, Korea. During his graduate courses in Seoul National University, he studied diffusion in biomaterials and bioinstrumentation. Also, he researched computer vision systems and the physical-physiological properties of biomaterials as a visiting scholar at Clemson University, USA.

Since joining the Korea Food Research Institute in 1990, he has studied food systems, process engineering, and bioinstrumentation including biosensor and food nanotechnologies. Currently he is serving as the head of the Bio-Nanotechnology Research Center, Korea Food Research Institute, and is an adjunct professor of the University of Science and Technology in Korea.

Dr. Cho has held several positions including the Chair of Division of Bioprocess Engineering as Korean Society for Agricultural Machinery, the Chair of the Research Group for Bio-molecules Measurement, and the Secretary General of the Federation of Korea Food Related Societies. Presently, he is the Secretary General of the Korea Society for Food Engineering, and the trustee of the Korea Nanotechnology Research Society.

He is the author of 111 peer-reviewed papers published in international and domestic journals and holds 34 patents. Dr. Cho has presented at numerous invited-lectures and he is the coauthor of three books on instrumentation and physical properties.

Sukwon Kang received his B.A. and M.S. degrees in agricultural engineering from the Seoul National University and his Ph.D. degree in biological and environmental engineering from Cornell University.

Dr. Kang was a research associate of the Agricultural Research Service at the U.S. Department of Agriculture and a researcher at Rutgers, the State University of New Jersey. He is currently a researcher at the National Academy of Agricultural Science at the Rural Development Administration since 2002.

He has conducted research and given presentations on advanced in food engineering. His current areas of research include optical engineering, such as near-infrared spectroscopy, hyperspectral and multispectral imaging techniques and computer vision, all with an emphasis on solving practical problems in food engineering.

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Contents

List of Figures vii
List of Tables xxi
Series Preface xxiii
Series Editor xxv
Preface xxvii
The Editors xxix
The Contributors xxxi

Chapter 1 Introduction 1
Yong-Jin Cho

Chapter 2 Instrumental Techniques for Measurement of Textural and Rheological Properties of Foods 5
Osvaldo H. Campanella

Chapter 3 Sensory Evaluation Using Artificial Intelligence 55
Seung Ju Lee

Chapter 4 Application of Computer Vision Systems for Objective Assessment of Food Qualities 79
Patrick Jackman and Da-Wen Sun

Chapter 5 NIR Spectroscopy for Chemical Composition and Internal Quality in Foods 113
Sukwon Kang

Chapter 6 Quality Measurements Using Nuclear Magnetic Resonance and Magnetic Resonance Imaging 149
Michael J. McCarthy, Sandra P. Garcia, Seongmin Kim, and Rebecca R. Milczarek

Chapter 7 Ultrasound Systems for Food Quality Evaluation 177
Ki-Bok Kim and Byoung-Kwan Cho

Chapter 8 Hyperspectral and Multispectral Imaging Technique for Food Quality and Safety Inspection 207

Moon S. Kim, Kuanglin Chao, Diane E. Chan, Chun-Chieh Yang, Alan M. Lefcourt, and Stephen R. Delwiche

Chapter 9 Electronic Nose for Detection of Food Flavor and Volatile Components 235

Bongsoo Noh

Chapter 10 Biosensors for Evaluating Food Quality and Safety 257

Namsoo Kim and Yong-Jin Cho

Chapter 11 Nanotechnology in Food Quality and Safety Evaluation Systems 307

Sanghoon Ko, Jae-Ho Kim, Bosoon Park, and Yong-Jin Cho

Index 335

List of Figures

FIGURE 2.1 Schematic description of a shear test for (a) liquids and (b) solids 9

FIGURE 2.2 Schematic diagram indicating the potential use of rheological properties in the food science and engineering areas 11

FIGURE 2.3 Schematic indicating different rheological behavior and classification, from a rheological standpoint, of nonelastic liquid foods 13

FIGURE 2.4 Schematic representation of typical flow curves for liquid foods in terms of (a) shear stress versus shear rate and (b) viscosity versus shear rate. (c) Typical viscosity versus applied viscosity for a plastic material exhibiting a yield stress 13

FIGURE 2.5 Schematic flow curve, in a double-logarithmic plot of viscosity versus shear rate, of a nonelastic non-Newtonian liquid over a wide shear range. The flow curve exhibits power law behavior at moderate shear rates and Newtonian behavior at extremely low and high shear rates 15

FIGURE 2.6 Flow curves of time-dependent non-Newtonian liquids obtained by increasing and decreasing the shear rates at a given rate. (a) Thixotropic liquids. (b) Rheopectic liquids 16

FIGURE 2.7 Typical test applied to thixotropic liquids to study recovery of their structure with time 17

FIGURE 2.8 Mechanical analogs to study viscoelasticity of foods along with their rheological models. (a) Elastic element. (b) Viscous (liquid) element. (c) Viscoelastic Maxwell (liquid) element. (d) Viscoelastic Kelvin-Void (solid) element 18

FIGURE 2.9 Typical results of small-amplitude oscillatory tests using shear flows. (a) Strain sweep test. (b) Frequency sweep test. (c) Temperature sweep test. (d) Time sweep test 21

FIGURE 2.10 (a) Schematic diagram illustrating a step strain relaxation test. (b) Generalized Maxwell mechanical analog used to describe step strain relaxation data 24

FIGURE 2.11 (a) Schematic diagram illustrating a step stress creep test. (b) Schematic diagram illustrating a recoil/recovery test 26

FIGURE 2.12 Schematic diagram illustrating the start-up flow test 27

FIGURE 2.13 Classification of commercial viscometers to determine the shear-based rheological properties of foods 28

FIGURE 2.14 Schematic of the geometry used to describe capillary viscometers using cylindrical geometries 34

FIGURE 2.15 Different approaches to determine ultrasound velocity and ultrasound attenuation of the food materials with the aim of characterizing their rheological properties 37

FIGURE 2.16 Schematic illustrating a system designed to measure the viscosity of liquids contained in a closed container using vibrations/acoustics at audible frequencies 39

FIGURE 2.17 Schematic of the oscillatory squeezing flow test to measure the viscoelastic properties of soft viscoelastic foods 40

FIGURE 2.18 Schematic of a system used to estimate the viscoelastic properties of a material with an irregular shape (e.g., corn grits) 41

FIGURE 2.19 Typical data resulting from the acoustic technique oscillatory squeezing flow in terms of the function mobility as a function of the applied frequency 42

FIGURE 3.1 Patterns of membership functions for fuzzy set 59

FIGURE 3.2 General form of a triangular fuzzy set and an alpha interval 60

FIGURE 3.3 Membership functions as the panel fraction versus mean intensity rating 64

FIGURE 3.4 A battery of fuzzy sets, C_1 to C_n, with triangular membership functions 65

FIGURE 3.5 (a) A graphical line scale. (b) Two fuzzy sets representing the line scale 65

FIGURE 3.6 Triangular membership for linguistic truth values clipped at $\mu_{T1} = 0.1$, $\mu_{T2} = 0.6$, $\mu_{T3} = 0.3$, $\mu_{T4} = 0$, and $\mu_{T5} = 0$ 67

FIGURE 3.7 Center-of-gravity defuzzification for an aggregated truth value t = 0.36 67

FIGURE 3.8 Fuzzy membership degrees for overall palatability of cooked rice samples A, B, C, and D. EX, excellent; GD, good; FR, fair; PO, poor; VP, very poor 68

FIGURE 3.9 Structure of artificial neural network 71

FIGURE 3.10 Mathematical process with transfer function 72

FIGURE 3.11 Types of transfer functions. (a, b) Less nonlinear. (c, d) More nonlinear. Net: v_k in Equation 3.21 73

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