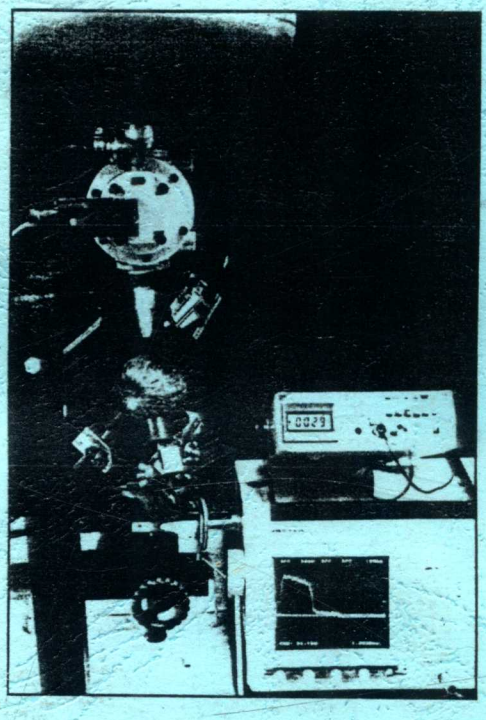
Nondestructive Food Evaluation

Techniques to Analyze Properties and Quality



edited by

Sundaram Gunasekaran

Nondestructive Food Evaluation

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University of Wisconsin–Madison
Madison, Wisconsin

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Preface

In the food industry, we are inherently limited by our inability to objectively, consistently, and accurately test food quality by our faculties of sight, sound, touch, taste, and smell. Fortunately, however, through many years of development, we have sensors that assist, and in many cases replace, human evaluations. Nonetheless, on-line control of food processes remains a major challenge in designing processes to consistently produce high-quality foods. The recent development of new sensors and measuring techniques has created several new opportunities to assist the food industry in this very important aspect of food manufacturing. Rapid, nondestructive, and on-line food quality evaluations can improve plant productivity and cost-effectiveness. Therefore, it is a very critical issue for the food industry. This book is a comprehensive treatise on most of the nondestructive methods for food quality evaluation and is designed to serve as a single reference source for. the industry and academia. Emphasis has been placed on the new and emerging methods and applications.

Nondestructive Food Evaluation is an edited volume with contributions from active researchers and experts in their topic areas. The book is divided into 10 chapters, each focusing on a major nondestructive techique, including optical, magnetic, ultrasonic, mechanical, and biological methods. Each chapter informs the reader of significant advances and offers insights for possible future trends in the nondestructive method.

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Optical techniques are presented under four topical headings (Chapters 1–4) to cover the wide span of electromagnetic spectrum: visible, IR, NIR, and FTIR; computer vision; delayed light and fluorescence; and x-ray tomography. Chapter 5 introduces the basic principles of nuclear magnetic resonance (NMR) and magnetic resonance imaging (MRI). NMR and MRI are nondestructive techniques that can be used to probe the physical and chemical properties and anatomical structure of biological materials. Therefore, the quality parameters associated with certain physical and chemical properties of foods can be evaluated by NMR and MRI. Use of NMR and MRI in analysis of water mobility, glass transition process, distribution of water and fat, and internal blemishes in foods is described.

Sound waves are transmitted through materials as compressions and rarefactions in their physical structure. Hence, it is often possible to relate the ultrasonic properties of a material to useful information about its macroscopic and microscopic composition. In Chapter 6, the physics of high-frequency sound is introduced, and applications of ultrasonic properties to monitor food quality are described.

Mechanical methods of nondestructive food evaluation include low-intensity impact (tapping) and vibration testing and high-pressure air impingement (Chapters 7 and 8). One of the most recent techniques used to evaluate food texture is the small-amplitude oscillatory strain test, popularly known as dynamic testing. In this test, a very small strain (less than 5%) is used to study the material structure–function relationships. Since food structure is the basis for its texture, this method offers the advantage of obtaining fundamental information about the eating quality of foods.

A taste panel traditionally measures many subjective food quality factors such as aroma and taste. Recent developments in providing objective, instrumented evaluations of such subjective factors are presented in Chapter 9, "Biosensors in Food Quality Evaluation." A good example of such class of sensor is the "electronic nose," which mimics the human sense of smell. The integration of multiple gas sensors and artificial intelligence has led to a new science of machine olfaction. Biosensors offer the advantage of rapid detection of bioactive components that can be measured and controlled to ensure food quality and safety. In food quality analysis and control, the data collected often are subjective and ill-conditioned. To infer useful information out of such data sets requires methods other than those traditionally used. Chapter 10 describes some of these data analysis procedures, such as neural networks, fuzzy logic, pattern recognition, and statistical process control.

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Sundaram Gunasekaran

Contributors

M. Mehmet Ak Department of Food Engineering, Istanbul Technical University, Maslak, Istanbul, Turkey

Paul L. Chen Department of Biosystems and Agricultural Engineering, University of Minnesota, St. Paul, Minnesota

John Coupland Department of Food Science, The Pennsylvania State University, University Park, Pennsylvania

Sudhir S. Deshpande Signature BioScience, Inc., Burlingame, California

Gabriel O. I. Ezeike Center for Food Safety and Quality Enhancement, Department of Food Science and Technology, The University of Georgia, Griffin, Georgia

Sundaram Gunasekaran Department of Biological Systems Engineering, University of Wisconsin—Madison, Madison, Wisconsin

Yen-Con Hung Center for Food Safety and Quality Enhancement, Department of Food Science and Technology, The University of Georgia, Griffin, Georgia

Joseph Irudayaraj Department of Agricultural and Biological Engineering, The Pennsylvania State University, University Park, Pennsylvania

David Julian McClements Department of Food Science, University of Massachusetts, Amherst, Massachusetts

Suranjan Panigrahi Department of Agriculture and Biosystems Engineering, North Dakota State University, Fargo, North Dakota

Stan Prussia Department of Biological and Agricultural Engineering, The University of Georgia, Griffin, Georgia

R. Roger Ruan Department of Biosystems and Agricultural Engineering, University of Minnesota, St. Paul, Minnesota

Muhammad Afzal Shahin Grain Research Laboratory, Canadian Grain Commission, Winnipeg, Manitoba, Canada

Jinglu Tan Department of Biological and Agricultural Engineering, University of Missouri, Columbia, Missouri

Ernest W. Tollner Department of Biological and Agricultural Engineering, Driftmier Engineering Center, The University of Georgia, Athens, Georgia

Contents

Preface *iii*
Contributors *vii*

1. Optical Methods: Visible, NIR, and FTIR Spectroscopy 1
Sundaram Gunasekaran and Joseph Irudayaraj

2. Computer Vision 39
Suranjan Panigrahi and Sundaram Gunasekaran

3. Delayed Light Emission and Fluorescence 99
Sundaram Gunasekaran and Suranjan Panigrahi

4. X-Ray Imaging for Classifying Food Products Based on Internal Defects 137
Ernest W. Tollner and Muhammad Afzal Shahin

5. Nuclear Magnetic Resonance Techniques and Their Application in Food Quality Analysis 165
R. Roger Ruan and Paul L. Chen

6. Ultrasonics 217
John Coupland and David Julian McClements

7. Firmness-Measurement Methods 243
Yen-Con Hung, Stan Prussia, and Gabriel O. I. Ezeike

8. Linear Viscoelastic Methods 287
M. Mehmet Ak and Sundaram Gunasekaran

9. Biosensors in Food Quality Evaluation 335
Sudhir S. Deshpande

10. New Techniques for Food Quality Data Analysis and Control 379
Jinglu Tan

Index *417*

1

Optical Methods: Visible, NIR, and FTIR Spectroscopy

Sundaram Gunasekaran
University of Wisconsin—Madison, Madison, Wisconsin

Joseph Irudayaraj
The Pennsylvania State University, University Park, Pennsylvania

I. INTRODUCTION

Food quality may be defined as the composite of those characteristics that differentiate individual units of a product and have significance in determining the degree of acceptability of that unit by the buyer (1). The quality of many products may be judged by the colors they display or fail to display. It is particularly critical in cases of food and biological products such as fruits and vegetables, cereal grains, and processed foods. The primary goal of quality control is to maintain a consistent standard of quality at a reasonable cost and at levels and tolerances acceptable to buyers.

Human evaluation has been the primary method of quality assessment for operations such as grading and sorting of food products, but such evaluation can hardly provide a general standard on a large scale and wide range of operations. Factors such as eye fatigue, lack of color memory, variations in color discrimination between individuals, personal bias, and variations in lighting conditions greatly influence an individual's decision when determining the quality of a certain product. Moreover, the human eye is greatly limited by its perceptions in a very narrow band of the vast electromagnetic spectrum. Some quality attributes, external and internal defects, and compositional factors are more readily detectable in the region outside the visible range, e.g., ultraviolet (UV) and infrared (IR). This has led to considerable research in developing instruments sensitive

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