Farid E. Ahmed, PhD
Editor

Testing of Genetically Modified Organisms in Foods

Pre-publication
REVIEWS,
COMMENTARIES,
EVALUATIONS . . .

"This book brings together, in one technically detailed volume, the collective experience of world-class experts in the field of GM testing. The result is an informed and balanced work describing existing and potential methods that can be used to detect the presence of GM in foods. This book is an invaluable resource for individuals in the food industry who carry out due diligence exercises on their products, regulators who wish to deepen their background knowledge on the effectiveness of tests, and of course, laboratory personnel of all levels who are involved in carrying out tests.

The chapters on molecular and immunological methods are authoritative and detailed in their scope and application. They are ably supported for the less-experienced reader by the basic instruction provided in the adjunct chapters. The instructive chapters describing the production of reference materials and sampling serve to provide a practical dimension, and remind the reader that a very real issue is being addressed.

The book describes the multifaceted industry that has grown around GM testing, since transgenic materials were first approved for food use. This comprehensive elucidation of the complexity and detail required to ensure that sampling and testing are effectively carried out as required by legislators will come as a surprise to many, and as a reassurance to others. I am looking forward to having a first edition copy of this important reference work on my bookshelf."

Sarah Oehlschlager, PhD
Team Leader, GM Testing,
Central Science Laboratory, United Kingdom
Ahmed masterfully weaves the reader through the complex, politically charged, and evolving field of food labeling. The authors provide the reader with balanced coverage of the complex issues associated with the risks and benefits of agricultural biotechnology, cover the regulations currently supporting food and feed labeling requirements, and provide a comprehensive review of the various analytical methods used to detect DNA and protein in food. This is a super source and a great desk reference for anyone considering developing sampling strategies and methods to support food and feed labeling requirements, for those new to the field of agricultural biotechnology, or for seasoned veterans struggling to keep up with the fast pace of this developing field.

Glen Rogan, MSc
Regulatory Affairs Manager, Monsanto Company

There is an increasingly overwhelming consensus among scientists and physicians that the current process for assessing the safety of GM crops as foods is adequate and that foods from crops that survive the regulatory process are as safe as conventionally produced foods. However, the public is generally not convinced, and has successfully convinced food companies and politicians that GM crops must be traced, with foods tested for GM content and labeled.

This book outlines in considerable detail methods that can be used to meet these labeling requirements, and is very balanced in its considerations of sampling methodology, reference material and standards, protein and DNA-based methods, and the limitations of near-infrared spectroscopic methods.

Rick Roush, PhD
Director, Statewide IPM Program, University of California
NOTES FOR PROFESSIONAL LIBRARIANS
AND LIBRARY USERS

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ABOUT THE EDITOR

Farid E. Ahmed, PhD, is Adjunct Professor of Radiation Oncology at the Leo W. Jenkins Cancer Center at the Brody School of Medicine, East Carolina University. He is also Director of GEM Tox Consultants, Inc., which is a consulting firm specializing in food safety, toxicology, and biotechnology. He has authored over 130 peer-reviewed scientific publications, serves on the editorial boards of several journals in toxicology, environmental sciences, and molecular pathology, and is a member of various scientific societies and educational organizations.
CONTRIBUTORS

Robert P. Cogdill, MS, Research Associate, AGROMETRIX/ Camagref, Montpellier Cedex 1, France.

Philippe Corbisier, PhD, Scientific Officer, European Commission, Joint Research Centre (EC-JRC), Reference Materials and Measurements Units, Institute for Reference Materials and Measurements (IRMM), Geel, Belgium.

John Fagan, PhD, CEO and Chief Scientific Officer, Genetic ID, Fairfield, Iowa.

Larry D. Freese, MS, Mathematical Statistician, United States Department of Agriculture, Federal Grain Inspection Service, Packers and Stockyards Administration, Technical Service Division, Kansas City, Missouri.

Claudia Paoletti, PhD, Scientific Officer, European Commission, DG JRC, Institute for Health and Consumer Protection, Biotechnology and GMO Unit, Ispra, Italy.

Sylvie A. Roussel, PhD, CEO, AGROMETRIX/Cemagref, Montpellier Cedex 1, France.

Heinz Schimmel, PhD, Scientific Officer, European Commission, Joint Research Centre (EC-JRC), Reference Materials and Measurements Units, Institute for Reference Materials and Measurements (IRMM), Geel, Belgium.

Anthony M. Shelton, PhD, Professor, Cornell University/New York State Agricultural Experimental Station, Department of Entomology, Geneva, New York.

James W. Stave, PhD, Vice President, Research and Development, Strategic Diagnostics, Inc., Newark, Delaware.
Stefanie Trapmann, PhD, Scientific Officer, European Commission, Joint Research Centre (EC-JRC), Reference Materials and Measurements Units, Institute for Reference Materials and Measurements (IRMM), Geel, Belgium.
Preface

This book addresses an important and emotionally charged issue in the food safety arena: eating food modified by organisms whose genetic material has been intentionally tampered with to introduce traits not normally present in the original food. This subject has attracted worldwide interest and is highly controversial in most countries due to differences in opinion as to the potential risks to human health and/or the environment associated with this procedure. These organisms, which are often called recombinant DNA, genetically modified, genetically engineered, bioengineered, or biotechnology manipulated organisms, are generally referred to as GMOs (genetically modified organisms), and the food is known as genetically modified or GM food. GMOs produce modified genetic material (i.e., DNA) and novel protein(s) in consumed food.

I have striven to produce a book (the first of its kind that is not produced as a result of a scientific meeting or proceedings of a symposium) that incorporates the latest developments in testing GMOs, and have tried to address the risks—whether real or imagined—that result from their presence in food. In addition, I have tried to present this information in a balanced way that incorporates all viewpoints and concerns raised by the various groups interested in the subject, including those from in the European Union, United States, and other countries.

Contributors to this book were selected from Europe and the United States on the basis of their recognized expertise in certain topics as demonstrated by their publications in the open reviewed literature and their presentations at public and scientific meetings. Thus, this book represents a state-of-the-art collection on the topic of genetically modified food and is a primary source of reference—worldwide—for college students enrolled in food safety courses, food technologists and scientists involved in testing GMOs (or attempting to establish testing methods in their respective laboratories), food handlers and suppliers of food ingredients, quality control/assurance staff, analytical chemists and molecular biologists working in the food sector, scientists and administrators within the regulatory frame-
work at all levels, and those at the sharp end of implementation of standards or involved in the provision of advice to the public, industry, or governments.

Contributors range from food and environmental scientists and analysts in academics or public research institutes who are dealing with the day-to-day issues raised by the monitoring and surveillance of these organisms to staff within the regulatory authorities who are continuously assessing the information and advice from all sources, to scientists in genetic testing facilities who are often involved in advising industry, governments, consumers, and consumer protection organizations on testing regimens worldwide.

Development of this book took place during ongoing legislation and regulatory debates in the European Union and the United States. The contents cover the areas of risks and benefits of GMOs in the food supply and the environment, sampling concepts and plans in both the European Union and the United States, reference material and standards, protein-based methods and DNA-based methods of testing, near-infrared spectroscopy, and other methods that may be of academic/research value or applicable to field testing (e.g., chromatographic, spectrometric, and nuclear magnetic resonance-based methods; biosensors; DNA chips and microarray technology; and new developments in proteomics research).

I hope that the overall combination of contributors and content, which brings together experts from opposite scientific and regulatory cultures candidly expressing their own views and beliefs, is timely and provides deeper insight into the issue at hand. Because a learning process is facilitated by considering the experiences of others with, perhaps, a different set of objectives, priorities, and beliefs, it is also hoped that the broad exchange of ideas lying within these chapters will help guide the reader to the real issues that impact consumers of food containing GMOs.

I gratefully acknowledge the amicable working relationships that developed between the authors, the publisher, and myself. Despite a variety of difficulties (e.g., ill health, work priorities, job pressures, and personal problems), chapters were diligently produced and my prodding queries and suggestions were patiently dealt with. I am also indebted to my family—my wife, Karen, and my sons, Khaled and Salah—for enduring my long work hours to produce this book in a timely manner, and to my colleague Roberta Johnke for her editorial help.
Chapter 1

Risks and Benefits of Agricultural Biotechnology

Anthony M. Shelton

THE DEVELOPMENT OF BIOTECHNOLOGY

Over the past 10,000 years, humans became food producers by increasing the numbers of domesticated plants and animals and modifying them through selective breeding. Only in the past century have breeders used techniques to create crosses that would not have been viable in nature, and this has been accomplished through modern biotechnology. The term biotechnology has evolved over time to take on new meanings, and it has become one of the most used and abused words in modern biology (Brown et al., 1987). In a broad sense it can be defined as using living organisms or their products for commercial purposes, and according to this definition, biotechnology has been around since the beginning of recorded history in animal and plant breeding, brewing beverages, and baking bread. A more modern definition focuses on the deliberate manipulation of an organism’s genes using a set of techniques of modern biology that employs living organisms (or parts of organisms) to make or modify products, improve plants or animals, and/or develop microorganisms for specific uses. Genetic engineering is one form of biotechnology that involves copying a gene from one living organism (plant, animal, or microorganism) and adding it to another organism. Today’s breeders may define a genetically engineered organism as a living thing that has been im-

I wish to thank the many scientists whose work has helped elucidate the many complex issues surrounding biotechnology, members of the Cornell Agricultural Biotechnology Committee for their fruitful discussions, and H. L. Collins for her help in preparing this chapter.
proved using genetic engineering techniques in which only a small piece of one organism’s genetic material (DNA) is inserted into another organism. Products of genetic engineering are often commonly referred to as “genetically engineered organisms,” “GE products,” “genetically modified organisms,” or “GMOs.”

The techniques employed in biotechnology, especially those used in genetic engineering, allow plants and animals, as well as many nonagricultural products such as medicines, to be developed in ways that were not thought possible only a few decades ago. The results have led to what is considered the third technological revolution, following the industrial and computer revolutions (Abelson, 1998). Discoveries in disciplines from physics to genetics have built on one another to progressively create today’s biotechnology. The work of James Watson, Francis Crick, Maurice Wilkins, and Rosalind Franklin in the early 1950s led to an understanding of the structure of DNA as the carrier of genes, the “inheritance factors” noted by the Austrian monk Gregor Mendel, who is often considered the founder of genetics. Others have followed in the long line of scientists who were able to use basic biology to understand how genes function in living organisms. In the late 1960s, Paul Berg delineated the key steps by which DNA produces proteins, and this became an important step in the future of recombinant DNA techniques and genetic engineering. Scientists soon came to realize that they could take specific segments of DNA that carried information for specific traits (genes) and move them into other organisms. In 1972, the collaboration of Herbert Boyer and Stanley Cohen resulted in the first isolation and transfer of a gene from one organism to a single-celled bacterium that would express the gene and manufacture a protein. Their discoveries led to the first direct use of biotechnology—the production of synthetic insulin to treat diabetes—and the start of what is often called modern biotechnology (Kelvess, 2001).

In the ongoing dialogue about biotechnology, it is important to understand how it is similar and how it differs from more traditional aspects of breeding. For example, traditional plant breeding relies on artificial crosses in which pollen from one species is transferred to another sexually compatible plant. The purpose of the cross is to bring desirable traits, such as pest resistance, increased yield, or enhanced taste, from two or more parents into a new plant. Plant breeding depends on the existence of genetic variation and desirable traits.