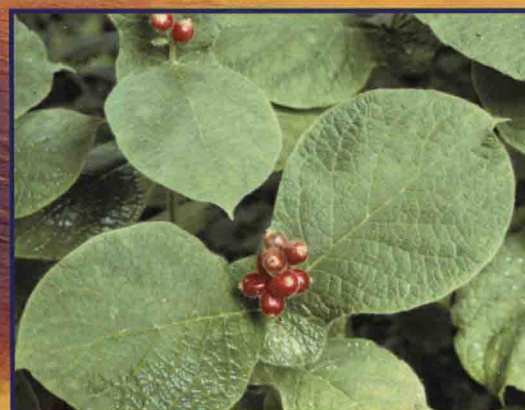


FOOD TOXICOLOGY

Edited by

Debasis Bagchi
Anand Swaroop

Foreword by **Sidney J. Stohs**



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FOOD TOXICOLOGY

Dedicated to my beloved father, the late Tarak Chandra Bagchi, MSc, AIC

Foreword



The World Health Organization estimates that over 350,000 people die of food poisoning around the world each year. Within the United States, the Centers for Disease Control and Prevention estimates that approximately one in every six Americans becomes ill each year as a result of food poisoning and foodborne diseases. In spite of numerous health and food-related regulations, approximately 130,000 people are hospitalized, while 3,000 people die annually in the USA as a result thereof. Many factors contribute to food-associated toxicities and poisonings.

Numerous steps may be involved in getting food from the farm or fishery to the dinner table, and as a consequence, contamination can occur at multiple sites along the food production chain. The industrialization and globalization of food production have introduced many additional opportunities for food to become contaminated with bacteria, viruses, molds, biological toxins, industrial toxins and wastes, pesticides, heavy metals, parasites, and plant and marine toxins.

The rapid, international production and shipping of food products around the world can result in widespread health problems when a food product is contaminated with a toxic or poisonous substance that can lead to delays in identifying the source and cause. In some cases, the consequences of food poisoning are rapid as may be the case for many bacterial and viral contaminations. Other cases of poisoning act more slowly and insidiously as is the case with drinking water contaminated with lead or a contaminated infant formula.

The consumption of foods is essential for life, and foods contain numerous essential nutrients as well as many other beneficial ingredients. However, it should be noted that the vast majority of the population believe that if something is “natural,” it is safe, in spite of the fact that the most toxic substances known come from natural sources. “Natural” is a word for which there is no official definition in the United States, although countries such as England and Canada have official definitions. Just because they occur in nature, many food ingredients are called natural within the United States, but they would not meet the definition of “natural” in either Canada or England.

It should also be kept in mind that various groups of people are at higher risk and have a greater susceptibility to various toxins and food poisons. Most notable are children under the age of 5 years due to their rapid growth, pregnant women, adults over the age of 65 years due to their decreased defense mechanisms, and immunocompromised individuals.

This book, *Food Toxicology*, edited by Dr. Debasis Bagchi and Dr. Anand Swaroop, provides current information on many aspects of food-related poisoning. It addresses several controversial topics and provides current information regarding food-related toxicity topics that have been problematic for years.

Sidney J. Stohs, PhD, FACN, CNS, ATS, FAPhA, FASAHP

Preface

Food toxicology demonstrates how natural or synthetic poisons/toxicants in diverse food products cause harmful, detrimental, or adverse side effects in living organisms. The term *toxicity* highlights the degree to which a compound can cause toxic manifestation (poisonous effects) and bodily injury. However, the degree of toxicity or the propensity of the harmful effect depends on the dose, duration (time), and route of exposure. The route of exposure includes oral (ingestion), topical, intravenous (directly into a vein), intramuscular (into a muscle), subcutaneous (under the skin), intraperitoneal (within the membrane lining the organs of the abdomen), or nasal (for gases and aerosols).

It is important to note that food toxicology is a very important area because the entire world population depends on the food supply chain, and any contamination or toxic manifestation may cause serious widespread adverse health effects. Also, this book covers a diverse area of food items including the processing, preservation of health-promoting constituents in the food and their vital integrity, storage stability, warehouse storing, refrigeration, supply and transportation, distribution, and catering. This includes raw foods and their proper preservation, and unprocessed and processed foods and their proper packaging, in conjunction with a number of parameters including storage temperature, preservatives, humidity, and shelf-life.

This book covers all possible intricate areas of food toxicology. The first chapter discusses the importance of dose-response in food toxicology, while Chapter 2 highlights the aspects on the measurement of toxicants and toxicity. The third and fourth chapters discussed the aspects of food-associated carcinogenesis and food-derived chemical carcinogenesis. Dr. Ramesh demonstrates how lipids potentiate toxicant absorption in the fifth chapter. The sixth chapter discusses the intricate aspects of food allergy. Chapter 7 highlights the diverse pathogens associated with fruits and vegetables and discusses how the incidences of pathogen contamination can be prevented. Chapter 8 exemplifies the safety issues of food ingredients from plant cell, tissues, and organ cultures. Dr. Stoev summarizes food security and foodborne mycotoxicoeses, risk assessment, prevention measures, and hazards in Chapter 9. Dr. Gerada discusses the detrimental effects of radionuclide exposure in foods in Chapter 10. Dr. April Neal-Kleuver and her diligent team have designed a vivid chapter on food-related toxicities in infants in Chapter 11. Chapter 12 considers naturally occurring toxicants as etiologic agents in foodborne diseases. Chapter 13 is dedicated to naturally occurring toxicants and antinutrients in plants and fungi. Drs. Hossain and Park provide an extensive review of mushroom toxins in Chapter 14. Chapter 15 on dioxin exposure via the food chain is addressed by Professor Sid Stohs, an eminently dedicated professor of toxicology. Chapters 16 through 18 extensively discussed the three most important heavy metal contaminants, namely, mercury, lead, and vanadium. Fluoride toxicity was extensively discussed in Chapter 19. The role of antioxidant additives in food preservation is considered in Chapter 20. Chapter 21 provides an overview of industrial food processing contaminants. Chapter 22 highlights how functional foods can target cancer stem cells and promote human health. Food packaging is a very critical aspect on food safety, and Chapter 23 is dedicated to this topic. Chapter 24 discusses the role of gut microbiome in human health and its modulation by environmental toxicants and therapeutic agents. The final chapter, Chapter 25, discusses various features including the pros and cons of genetically modified foods and how they will participate in the biotech revolution and human health in the future.

Finally, the foreword of this book was written by my respected and beloved guru (teacher) Sidney J. Stohs, PhD, FACN, CNS, ATS, FAPhA, FASHP, dean emeritus of the School of Pharmacy and Health Professions at Creighton University Medical Center, Omaha, Nebraska, who taught me the intricate aspects of toxicological sciences.

We sincerely acknowledge and thank all the contributing authors for their valuable contributions to this book, and we expect that the book will be useful to readers. The editors sincerely thank Namrata Bagchi, Tariq Ahmad and Randy Brehm for their continued technical support, suggestions and assistance.

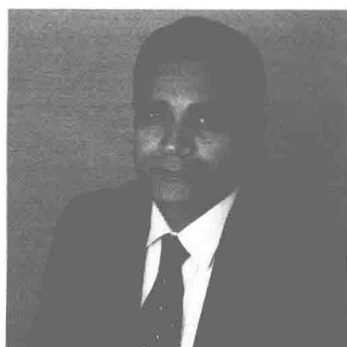
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Editors



Debasis Bagchi, PhD, MACN, CNS, MAIChE, earned his PhD in medicinal chemistry in 1982. He is an adjunct professor in the Department of Pharmacological and Pharmaceutical Sciences at the University of Houston College of Pharmacy, Houston, Texas, and the chief scientific officer of Cepham Research Center, Piscataway, New Jersey. Dr. Bagchi is an adjunct faculty in Texas Southern University, Houston, Texas. He served as the senior vice president of Research & Development of InterHealth Nutraceuticals Inc., Benicia, California, from 1998 to February 2011, and then as the director of innovation and clinical affairs of Iovate Health Sciences, Oakville, Ontario, until June 2013. Dr. Bagchi received

the Master of American College of Nutrition (ACN) Award in October 2010. He is the former chairman of International Society of Nutraceuticals and Functional Foods (ISNFF), former president of ACN, Clearwater, Florida, and former chair of the Nutraceuticals and Functional Foods Division of Institute of Food Technologists (IFT), Chicago, Illinois. He is serving as a distinguished advisor on the Japanese Institute for Health Food Standards (JIHFS), Tokyo, Japan. Dr. Bagchi is a member of the Study Section and Peer Review Committee of the National Institutes of Health, Bethesda, Maryland. He has 315 papers in peer-reviewed journals, 27 books, and 18 patents. He is also a member of the Society of Toxicology, a member of the New York Academy of Sciences, a fellow of the Nutrition Research Academy, and a member of the TCE stakeholder committee of the Wright Patterson Air Force Base, Ohio. Dr. Bagchi is the associate editor of the *Journal of Functional Foods*, *Journal of the American College of Nutrition*, and *Archives of Medical and Biomedical Research* and also serves as editorial board member of numerous peer-reviewed journals, including *Antioxidants & Redox Signaling*, *Cancer Letters*, *Toxicology Mechanisms and Methods*, and *The Original Internist*.



Anand Swaroop earned his MS in biochemistry and PhD in chemistry in 1997. He has gathered over two decades of diversified global management experience in phytopharmaceuticals, global regulations on nutraceuticals and functional foods, chemicals and pharmaceutical ingredients, outsourcing and supply chain management, business development, market research, and strategic planning. He has worked in various multinational pharmaceutical companies, including Alembic Pharmaceuticals Limited (Vadodara, India), Cadila Pharmaceuticals Limited (Ahmedabad, India), Nandesari Rasayane Limited (Vadodara, India), and Dai-Ichi Laboratories Limited (Hyderabad, India),

and Yag Mag Labs Pvt Limited (Hyderabad, India) in senior management positions. Currently, he is the founding president of a reputable group of companies including Cepham Inc. (Piscataway, New Jersey), Yag Mag Inc. (Piscataway, New Jersey), RALLIFE Inc. (Piscataway, New Jersey), and Cepham Life Sciences Inc. (Piscataway, New Jersey). Dr. Swaroop has introduced several cutting-edge nutraceutical ingredients for obesity, diabetes, metabolic syndrome, and versatile degenerative conditions in the United States and around the world. He has 12 peer-reviewed publications, two books with CRC Press/Taylor & Francis Group and Wiley-Interscience, and numerous patents. Dr. Swaroop is a member of the American Chemical Society, American Association of Pharmaceutical Scientists, American Society of Pharmacognosy, the New York

Academy of Sciences, the American College of Nutrition, the Council for Responsible Nutrition, the American Botanical Council, and the Natural Products Association. He has organized and chaired numerous sessions in the annual meetings of the Institutes of Food Technologists, the International Society of Nutraceuticals and Functional Foods, and other scientific meetings. He has delivered invited lectures and served as session chairs in various national and international scientific conferences and organized workshops and group discussion sessions.

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