

SECOND EDITION

# FOOD SCIENCE

An Ecological Approach



EDITED BY

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*This book is dedicated to my beautiful daughters, Jodi Rachael and Staci Michelle. No mother could be prouder of the women you have become. And, with this edition of the book, you both have become mothers. We are so blessed.*



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# Preface

## Why the Ecological Approach?

The subject of food science includes the study of plant and animal sources at the cellular level. Different species have evolved based on their environments and genetic changes over time. Ecological changes can have devastating consequences for a plant or animal species. For example, the Irish potato famine that occurred in the 1800s was the result of a virulent fungus (*Phytophthora infestans*) whose spores were spread by wind. Similarly, droughts, such as that seen in 2011 in Somalia, can have a negative effect on animal and plant life in a region. The role of food scientists in these types of scenarios is to potentially find plants that are able to survive in such changing environmental conditions.

Food scientists are being challenged to find and develop plant and animal species that are more tolerant of the Earth's changing ecology (natural or manmade) in order to provide food that is rich in nutrients (food composition and quality), cost-effective, and available to all people (food technology and delivery systems).

Let us examine some of the environmental changes (natural or manmade) that may affect the world's food supply in the future:

- *Increases in average temperature.* An increase in the average temperature in a region can (1) lengthen the growing season in regions with a relatively cool spring and fall, (2) adversely affect crops in regions where summer heat already limits production, (3) increase soil evaporation rates, and (4) increase the chance of severe drought.
- *Changes in rainfall amounts and patterns.* Changes in rainfall can affect soil erosion rates and soil moisture, both of which are important for crop yields. In addition, it is predicted that climate change will increase the number of extreme precipitation events.
- *Increases in pollution levels.* Higher levels of ground-level ozone will limit the growth of crops. Because ozone levels in the lower atmosphere are shaped by both emissions and temperature,

climate change will most likely increase atmospheric ozone concentrations.

- *Change in climatic variability and extreme events.* Increased frequency and severity of heat waves, drought, floods, and hurricanes are a potential result of climate change.

This text examines food science within the context of the modern world we live in. Although the scientific principles remain the same, they must be viewed through a new lens, one that marries food science with present-day concerns regarding food quality, composition, and availability. Each chapter of this textbook brings to light some of these challenges facing food scientists.

This text approaches food science from an ecological perspective. The science of food remains at the very core of this book, as reflected by the concepts and principles that students are required to master. Section I of *Food Science: An Ecological Approach, Second Edition* presents the introductory concepts students studying food science are required to learn. Using concise language and an engaging writing style, these foundational chapters provide students with the background to understand the relationship between food science and the environment, research methods used by food scientists, and the underlying science and chemistry behind food composition.

**Chapter 1, "Food Science in an Era of Environmental Concern,"** anchors food science within the natural environment. After reading this chapter, students will be able to conceptualize how environmental conditions affect food composition and sources. Principles such as ecosystems, crop yield, sustainable agriculture, and biodiversity are just some of the important concepts introduced in the chapter.

**Chapter 2, "How Food Science Is Guided by Research,"** presents the traditional evidence-based research models that students will need to embrace as a part of validating food science facts. Chapter 2 also explores some of the various types of scientific studies, including analytical studies; case-control studies; case reports and case series; cohort studies; cross-sectional surveys; descriptive studies; double-blind, placebo-controlled designs; hypothesis testing; intervention studies; longitudinal surveys; observational studies; population or correlational studies; and randomized designs.

**Chapter 3, “Food Evaluation,”** discusses the traditional sensory evaluation techniques food scientists use for taste tests. After reading this chapter, students will understand traditional taste panel methods, product and panelist control, sensory tests, and test scaling.

**Chapter 4, “Food Composition,”** establishes students’ foundational knowledge of the chemical structures and chemical reactions common to food. This foundational knowledge is critical to understanding the later chapters of the text. The chapter presents the chemical building blocks of foods through discussion of carbohydrates, starches, lipids, proteins, vitamins, and minerals.

Section II of *Food Science: An Ecological Approach, Second Edition* primarily provides a focused discussion of the types of food and the science behind each. Using a consistent presentation, each chapter discusses each food’s historical, cultural, and ecological significance; its physical and chemical properties; preparation techniques and food safety concerns; and its impact on health.

**Chapter 5, “Food Safety,”** identifies current national food safety issues and the agencies responsible for the safety of the U.S. food supply. It also identifies organisms that may be disseminated by ingestion and the foods most at risk for contamination, and it offers recommended actions that dietitians and other professionals can take to promote food safety preparedness.

**Chapter 6, “Vegetarianism,”** presents information on the different types of vegetarian diets and the prevalence of vegetarianism in the United States. The chapter compares the health effects of vegetarian, vegan, and omnivorous diets.

**Chapter 7, “Meat and Meat Substitutes,”** delves into the study of meat and meat substitutes. Content coverage includes muscle structure, meat cuts, and factors affecting the composition of meat.

**Chapter 8, “Fish,”** explores the structure of fish as well as nutritional and environmental issues with regard to raising fish, endangerment, and consumption.

**Chapter 9, “Poultry,”** explores the structure of poultry as well as nutritional and environmental issues with regard to poultry safety, free-range farms, and human health.

**Chapter 10, “Milk, Cheese, and Dairy,”** presents milk and dairy products. Topics include issues pertaining to the production and purchase of milk and dairy products and their uses in recipes.

**Chapter 11, “Eggs and Egg Replacements,”** examines egg-related food science topics such as egg production, quality, and grading and the use of eggs in cooked foods.

**Chapter 12, “Fruits and Vegetables,”** presents the classification of fruits and vegetables. It also includes a discussion of the structural parts of fruits and vegetables and the various types of pigments present in plant products. Students will learn about the health benefits of plants as a source of phytonutrients and their use as functional foods.

**Chapter 13, “Grains, Cereals, Pasta, Rice, Flour, and Starch Cookery,”** presents the food science behind grains,

cereals, pastas, and starch cookery. Students will learn about the different types of grains and cereals. The anatomy of grains and cereals and various cooking methods are also discussed. A special feature on the use of starch thickeners for use in dysphagia is also provided.

**Chapter 14, “Yeast Breads, Quick Breads, and Cakes,”** focuses on yeast breads, quick breads, and cakes. Particular attention is paid to the mixing, kneading, rising, and baking of yeast breads. The preparation of cakes and quick breads is also discussed. Students will learn about the role of various ingredients in the preparation of doughs and batters.

**Chapter 15, “Fats and Oils,”** discusses the role of fats and oils in food science. Among the topics discussed are saturated fats, monounsaturated fats, and fat substitutes. The effects of heat on fats and oils are explored. The effects of rancidity on foods are also presented.

**Chapter 16, “Sugar and Sugar Substitutes,”** introduces students to the structure of sugar and sugar replacements, as well as their use in baked goods and other products. Students will become familiar with the different sources of sugar, its chemical properties, and its use in baked goods and candy making. A detailed discussion of the various sugar replacements is also provided.

**Chapter 17, “Beverages,”** focuses on coffee, tea, and sports drinks, discussing the composition, quality, and nutritional benefits of each. Focused discussions of soda, wine, and liquors are presented individually through Special Topics features within the chapter.

**Chapter 18, “Food Preservation and Packaging,”** presents the most current information related to food preservation and packaging. Traditional methods of food preservation are discussed, including heat treatments, freezing, drying, and irradiation. New technologies, such as high pressure treatments, pulsed light, and ultrasound technology, and the use of alternative chemicals, are also presented. Different methods and materials for food packaging are also discussed.

## New to the *Second Edition*

Based on feedback collected from instructors who adopted the first edition, a number of large- and small-scale changes have been implemented for the second edition of *Food Science: An Ecological Approach*.

Most notably, Chapter 5, “Food Safety,” is new to this edition. Among other things, this chapter identifies the safety issues that most threaten our food supply, and it also describes actions that dietitians and other health professionals can take to promote safety. Additionally, the single chapter on poultry and fish in the first edition has been separated into two chapters—Chapter 8, “Fish,” and Chapter 9, “Poultry”—thus providing more well-rounded coverage of each. Finally, a Case Study has been appended to the end of each chapter, providing students with the opportunity for practical application of the content.

The following list highlights specific content areas that have been updated, expanded, or added for the *Second Edition*:

- **Chapter 1: “Food Science in an Era of Environmental Concern”**
  - Potential impacts of planetary health, planetary boundaries, and biodiversity loss on food science, and the potential role of diet in protecting our planetary boundaries and mitigating climate change
  - Examples of how environmental nutrition and sustainable diets can be applied to reduce human impact on the natural environment
  - Description of the Paris Agreement signed in 2016
  - The role of vegetarianism and plant-based diets in stabilizing the climate
  - The effects of eating locally
  - The impact of food waste on climate change
  - Resource utilization
  - Water conservation and drought
  - Opposing impacts of palm oil and lentils
  - Agrichemicals
  - Plastics debris
  - Antibiotic resistance stemming from the food supply
  - Concern for the natural environment among health professionals
- **Chapter 2: “How Food Science Is Guided by Research”**
  - *Healthy People 2020* Criteria
  - *Dietary Guidelines for Americans, 2015–2020*
  - MyPlate, MyWins
- **Chapter 3: “Food Evaluation”**
  - New section regarding objective evaluation using both physical tests and chemical tests, with coverage of the following:
    - Principles and approaches
    - Selected devices used to apply such approaches
- **Chapter 4: “Food Composition”**
  - Water research for cleanliness and composition (e.g., Michigan lead issues)
  - Sterols as functional foods
  - Research concerning pH in canning food
  - Maillard reaction chemical changes
  - Chemical structures
  - Fortification and enrichment updates
  - Retrogradation
  - 2018 laws concerning trans fat in food
- **Chapter 5: “Food Safety”—*Completely new to this edition!***
- **Chapter 6: “Vegetarianism”**
  - Relevant portions of the *Dietary Guidelines for Americans, 2015–2020*
  - Highlights from new research on the benefits of fiber
  - Non-dairy and animal protein replacements
  - International/global stats on health and disease
  - Organizations supporting a plant-based diet
  - Recent research findings on vegetarian diets
  - Nutritional deficiencies in the typical American diet, with recent research on low intake of specific vegetables in the United States
  - Technology creating meat substitutes
  - Vegetarian meal planning
  - New research on nutritional ecology
  - Government guidelines for greener diets, with new dietary guidelines for China as a significant example
- **Chapter 7: “Meat and Meat Substitutes”**
  - Beef vaccines
  - Beef imports
  - Recent beef and other meat consumption statistics
  - Swine flu update
  - *E. coli* growth and storage
  - Dietary guidelines on fat intake
  - Processed meat as carcinogens
  - “Food Keeper” app
  - Porcine epidemic diarrhea virus
- **Chapter 8: “Fish”**
  - Fish farming and harvesting
  - Ecosystem approach to fishing
  - Good agricultural practices
  - Good manufacturing practices
  - HACCP and fish safety
- **Chapter 9: “Poultry”**
  - Muscle fibers in poultry
  - Poultry as a functional food
  - Fat types in poultry
  - Nutritional statistics
  - Hemichrome (iron) in poultry
  - Poultry consumption statistics
  - Poultry processing
- **Chapter 10: “Milk, Cheese, and Dairy”**
  - Pasteurization additions as HTST and ultrapasteurization
  - Kefir processing
  - Innovation Point on rennin
  - Unripened cheese
  - Obesity and dairy product research
  - Muscle recovery and dairy product research
  - Table of calcium content from dairy sources



- Labeling of frozen dairy products
- Yogurt consumption and Type II diabetes prevention
- Oral health, osteoporosis, and hypertension prevention
- **Chapter 11: “Eggs and Egg Replacements”**
  - Avian flu update
  - Egg cookery in differing cultures
  - Additional Gastronomy Point regarding egg emulsions
  - Nutraceuticals in eggs
  - Move toward cage-free egg use
  - Updates in egg preparation and salmonella outbreak prevention
  - External egg parasites
  - Recent salmonella outbreak statistics
- **Chapter 12: “Fruits and Vegetables”**
  - Updates in the physical and chemical properties of fruits and vegetables
  - Plant cell structure
  - Effects of boiling on vegetables
  - Healthy bacteria produced in the digestion of produce
  - Hydroponics
- **Chapter 13: “Grains, Cereals, Pasta, Rice, Flour, and Starch Cookery”**
  - Rice and arsenic
- **Chapter 14: “Yeast Breads, Quick Breads, and Cakes”**
  - Gluten structure and the results of over- or undermixing
  - Surfactants as bread softeners
  - Enzymes as catalysts
  - Vital wheat gluten
  - Yeast nutrients
  - pH regulators
  - Maillard reaction, caramelization, and acrylamide in baking
  - Baking soda/powder effects on baked goods
- **Chapter 15: “Fats and Oils”**
  - Inclusion of *Dietary Guidelines for Americans, 2015–2020* comments on cholesterol
  - FDA statement on partially hydrogenated oils
  - Coconut oil nutrient content
  - Oxidative rancidity and free radicals
  - Unsaturated fat and oxidation
- **Chapter 16: “Sugar and Sugar Substitutes”**
  - Gastronomy Point update on prebiotic/probiotic fermentation
  - Chemical structures of sugar substitutes
  - Special Topic added on supertasters and sweet/bitter tastes
  - Digestive issues and FODMAP fermentable oligosaccharides, disaccharides, monosaccharides, and polyols
  - Sugar’s role in canning
- **Chapter 17: “Beverages”**
  - New research on coffee’s effect on health
- **Chapter 18: “Food Preservation and Packaging”**
  - Updates from the *Dietary Guidelines for Americans, 2015–2020* on sodium intake and processed food
  - New York’s regulation for sodium in restaurant and packaged food
  - Updates in the Food Quality Protection Act
  - FDA update on biphenol A (BPA) in infant bottles

## The Complete Learning Package

A full suite of resources are available to instructors using *Food Science: An Ecological Approach, Second Edition* in their classroom. These include the following:

- Test Bank, containing more than 500 questions
- Slides in PowerPoint format, featuring more than 400 slides
- Image Bank, collecting photographs and illustrations that appear in the text
- Instructor’s Manual, including an array of useful instructor tools:
  - Lecture Outlines
  - Teaching Tips
  - Chapter Review Questions
  - Student Activities
  - Answers to the end-of-chapter Case Studies

Additional student resources are available online and include the following:

- Lab Manual featuring recipes correlated to chapter content
- Interactive eBook containing Knowledge Check Questions tied to major headings in the text
- Interactive Flashcards that allow students to test their knowledge of key terms

## Special Topic

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### Careers in Food Science

#### *Jackeline Barreto and Sari Edelstein*

A food scientist, or food technologist, looks for better ways to select, preserve, process, package, and distribute food products, including the ingredients that go into them. A food scientist also must have extensive knowledge about the nature, composition, and behavior of food, such as what happens to its flavor, color, or nutritional properties when cooked or placed in storage. Biology, microbiology, chemistry, and engineering are just some of the diverse fields of study that food science draws upon to ensure safe, high-quality consumer products.<sup>1</sup>

Food scientists and technologists usually work at universities or food processing facilities. Their main objective is to improve food products by finding a more effective and efficient way to preserve, package, store, or deliver foods. It is the responsibility of the food scientist to analyze and determine the nutritional content of the food with respect to carbohydrates, fats, proteins, sugars, vitamins, minerals, and so on. In addition, food scientists work with government agencies and corporations to make sure food safety, food quality, food waste, and food disposal regulations are being met.

Food scientists may be involved in discovering new food sources; analyzing a food item to determine its vitamin, fat, sugar, or protein content; or searching for substitutes for harmful or undesirable additives, such as nitrites. Other food scientists may engage in applied research, finding ways to improve the content of food or to remove harmful additives. Food scientists are also involved in exploring better ways to process, preserve, package, or store food according to industry and government regulations. Some continue to research improvements in traditional food processing techniques, such as baking, blanching, canning, drying, evaporation, and pasteurization.<sup>2</sup>

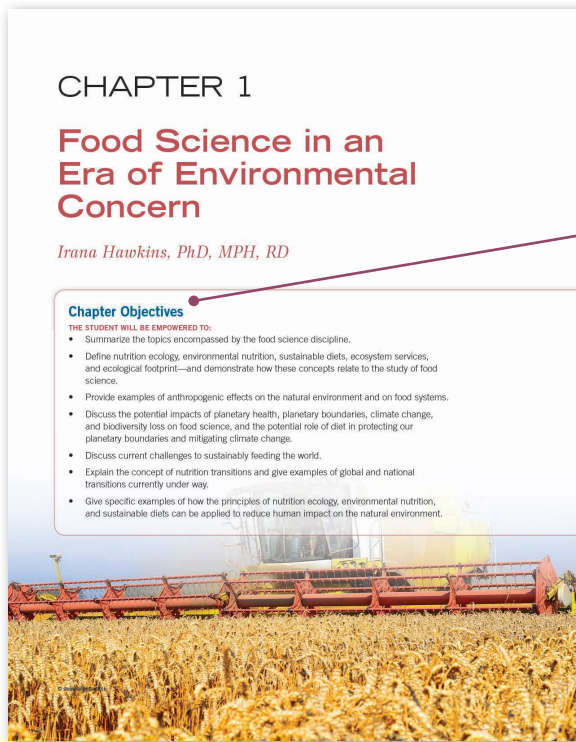
Because of the wealth of knowledge that food scientists must draw upon, a career in food science requires a bachelor's degree, but a master's or doctorate is often preferred. Some states require that certain food scientists have proper licensure, such as that required for soil scientists. Today, food scientists/dietitians are working in the United States, and job growth for food scientists is greater than average compared to other occupations. It can also be a well-paying career, with a median annual salary of \$58,920. Employment in this profession is projected to grow faster than average at 14% between 2016 and 2026.<sup>3</sup>

#### References

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## Features of This Text

*Food Science: An Ecological Approach, Second Edition* incorporates a number of engaging pedagogical features to aid in the student's understanding and retention of the material.



Each chapter starts with **Chapter Objectives**, which highlight the critical points of each chapter.

**Key Terms** are defined throughout the chapter to enhance comprehension. A glossary is now included at the end of the text.

**Nutrient content claim** Statement that a food company can place on a product label that reflects the product's nutrient content. For example, a package label may state that the product "Contains 100 calories." Companies also can state that a particular food is a "good source" of a nutrient or that a food is a "high" source of a nutrient.

### Chapter Review

Foods are complex systems; their nutritional value and behavior under normal handling conditions are dependent on their composition. The high-water activity of most fresh produce, meat, fish, and milk makes these food systems very susceptible to spoilage due to microbial and chemical reactions. Many food preservation methods, such as dehydration, freezing, and the addition of high amounts of salt or sugar, aim to reduce the water activity levels in the target food systems.

Carbohydrates are the primary source of calories in the human diet. In food processing, they are important as sweeteners, bulking agents, and texture modifiers (through starch gelatinization). They also are the reactants in caramelization and Maillard reactions. Lipids are the most energy-dense nutrients and contribute to a food's mouthfeel, texture, and flavor, while also providing for extended satiety after a meal. Fats are lipids that are in a solid state at room temperature, whereas oils are lipids that are liquids at room temperature. The liquid state of oils is attributed to the presence of double bonds in the constituent fatty acids, which lowers their melting points. In foods, fats are used to shorten gluten fibers during baking, oils are used as media for heat transfer, and phospholipids are used as emulsifiers. Proteins are complex polymers of amino acids. Heat-coagulated egg proteins in soufflés and custards, acid- or enzyme-coagulated milk proteins in cheese, enzymes such as pectinases used for minimizing cloudiness in fruit juices, and the use of the enzyme rennin for cheese making are just some of the most commonly encountered food applications of proteins. The sensory acceptance of foods often relies on the chemical interactions that occur in water involving carbohydrates, proteins, and their derivatives.

At the end of each chapter, a **Chapter Review** summarizes key ideas and helps students remember the different concepts discussed in the chapter and how the concepts interrelate.

For this edition, a **Case Study** has been added to each chapter, allowing students to apply critical-thinking skills to an issue relevant to the chapter. Instructors can find suggested answers in the Instructor's Manual.

**Case Study**

**Finding Evidence-Based Answers**

A number of questions in the nutrition literature have not really been answered using an evidence-based approach. Examples include "Does fast food intake increase weight in children?" and "Why did the recommendation for intake of added sugars fall from 25% of energy intake in the *Dietary Guidelines for Americans, 2010* to 10% of energy intake in the *Dietary Guidelines for Americans, 2015*?"


**Question**

1. Working in teams, pick either of these questions or a question you develop with your instructor and see if you can come to a definitive answer using an evidence-based approach.

A list of **Key Terms** is provided at the end of the chapter for ease of student review.

Each chapter offers a **Learning Portfolio**, which features a variety of tools to assist student learning.

92 CHAPTER 2 HOW FOOD SCIENCE IS GUIDED BY RESEARCH



## Learning Portfolio

**Key Terms**

Case control study	56
Case report	56
Case series	56
Cohort study	57
Cross-sectional survey	56
Dietary guidelines for Americans	80
Double-blind placebo-controlled design	57
Health claim	87
Intervention study	57
Metabolic diet study	71
Nutrient content claim	87
Population or correlational study	56
Randomized design	57
Structure/function claim	88

**Study Points**

1. The peer-reviewed literature is the gold standard for scientific information provided to the public, as well as for the information used when setting recommendations and policies, designing and evaluating nutrition programs, and conducting ethical evidence-based food and nutritional sciences, including dietetics practice.
2. Descriptive studies are used for hypothesis generation and include population or correlational studies, case reports, case series, and cross-sectional surveys.
3. Analytical studies are used to test hypotheses and include case control studies, cohort studies, and intervention studies. In a randomized design, individuals are randomly assigned to a treatment or control group. In a double-blind placebo-controlled design, neither the individuals nor the investigator knows whether participants are assigned to a treatment or a placebo group. This study design is usually considered to provide the most compelling evidence of a cause-and-effect relationship.

**Issues for Class Discussion**

1. Dietary recommendations for the public change as scientific studies discover new information. How can these changes be brought to the public's attention in a way that does not cause confusion or resentment?
2. What ethical responsibility, if any, does industry or the media have in promoting the public's health?
3. The *Dietary Guidelines for Americans* and MyPlate, MyWins advocate prudent diets, but Americans clearly have difficulty following these recommendations. Why is this the case? If people are unable to follow the recommendations, should the government continue to make them?

**Research Areas for Students**

1. Major nutrition research studies and the dietary changes that were recommended
2. Major food studies and the composition of the foods recommended for consumption

**References**

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10. Texas Department of Aging and Disability Services. DETERMINE Your Nutritional Health Screening Initiative. <http://www.dads.state.tx.us/providers/AAA/Forms/standardized/NRA.pdf>. Accessed October 29, 2016.

**Study Points** provide the student with an outline of key points presented in the chapter.

**Issues for Class Discussion** provides an opportunity for student reflection about the chapter content. Many new issues have been incorporated for this edition due to increasing environmental concerns surrounding our food supply.

**Research Areas for Students** provide suggestions for further research on the topics covered in the chapter and emphasize the need for peer-reviewed material.

Each Learning Portfolio concludes with a list of updated **References**.



A comprehensive and instructional **art package** includes color photographs and illustrations throughout this text to encourage learning with a unique visual appeal.

**Green Points** provide contextual suggestions for living a sustainable lifestyle.

### *Green Point*

**Rice Packaging** Some rice producers have reduced packaging material by approximately 15% by removing the reusable zippers in their 2-pound rice bags, saving 35,000 pounds of plastic from entering landfills yearly.

### *Gastronomy Point*

**Nuts as Snacks** The high amounts of fiber, protein, and healthy fats make nuts a perfect, satisfying snack. Pair a handful of nuts with a piece of fruit or make a portable trail mix using dried fruit, popcorn, cereals, and/or chocolate chips.

**Gastronomy Points** discuss cooking methodologies as they pertain to the chapter.

**Phytonutrient Points** discuss the health benefits of food components.

### *Phytonutrient Point*

**Alpha-Linolenic Acid** Alpha-linolenic acid—which is found in flaxseed, walnut, and canola oils—can be converted into DHA and EPA, although the efficiency of conversion is very low in the human body. Nevertheless, it is an important omega-3 fatty acid, especially in a vegetarian diet.

## Innovation Point

### Technologies to Minimize *Trans*

**Fats** New technologies are being developed to decrease or eliminate *trans* fats through the production of blends. Blends are mixtures of oils with reduced percentages of *trans* fatty acids and saturated fatty acids. In some instances, hydrogenated oils are used, but in smaller percentages, along with a tropical oil or nonhydrogenated oil.

**Innovation Points** discuss developments in the field of food science.

**Special Topics** pay particular attention to singular points featured throughout the chapter.

### Special Topic 4.1

#### Phytonutrients and Functional Foods

Lalitha Samuel, PhD

Simply put, **phytonutrients** (or *phytochemicals*) are non-nutritive chemicals derived from plants. Unlike carbohydrates, fats, proteins, vitamins, and minerals, phytonutrients are not essential for life; however, they can promote good health. They are found in vegetables and fruits, whole grains, herbs, teas, and spices. A summary of various phytochemicals and their food sources is provided in **Table A**.

**TABLE A**  
Phytochemicals Found in Different Plant-Based Foods

Phytonutrient	Food Sources
Anthocyanidins	Berries, cherries, red grapes
Beta-carotene	Carrots, various fruits
Caffeic acid, ferulic acid	Apples, pears, citrus fruits, some vegetables
Diallyl sulfide, allyl methyl trisulfide	Garlic, onions, leeks, scallions
Dithiolthiones	Cruciferous vegetables such as broccoli, cabbage, bok choy, collard greens
Flavanols (catechins, epicatechins, procyanidins)	Tea, cocoa, chocolate, apples, grapes
Flavanones	Citrus fruits
Flavonols	Onions, apples, tea, broccoli
Lutein, zeaxanthin	Kale, collard greens, spinach, corn, citrus fruits
Lycopene	Tomatoes, processed tomato products
Proanthocyanidins	Cranberries, cocoa, apples, strawberries, grapes, wine, peanuts, cinnamon
Sulforaphane	Cauliflower, broccoli, Brussels sprouts, cabbage, kale, horseradish

Modified from Newell-McGloughlin M. Impact of biotechnology on food supply and quality. In: Damodaran S, Parkin KL, Fennema, OL, eds. *Food chemistry*. Boca Raton, FL: CRC Press; 2008:1076-1077.



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