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# Understanding Food Principles and Preparation

SIXTH EDITION

**Amy C. Brown**  
University of Hawaii at Manoa



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**Amy C. Brown**

Product Director: Dawn Giovanniello

Product Manager: Krista Mastroianni

Project Manager: Ronald D'Souza

Content Developer: Oden Connolly

Product Assistant: Marina Starkey

Marketing Manager: Ana Albinson

Manufacturing Planner: Karen Hunt

Photo and Text Researcher:

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# Brief Contents

## PART I FOOD SCIENCE AND NUTRITION

- 1 Food Selection 1
- 2 Food Evaluation 20
- 3 Chemistry of Food Composition 27

## PART II FOOD SERVICE

- 4 Food Safety 61
- 5 Food Preparation Basics 91
- 6 Meal Management 113

## PART III FOODS PROTEIN—MEAT, POULTRY, FISH, DAIRY, & EGGS

- 7 Meat 131
- 8 Poultry 163
- 9 Fish and Shellfish 177
- 10 Milk 197
- 11 Cheese 218
- 12 Eggs 236

## PHYTOCHEMICALS— VEGETABLES, FRUITS, SOUPS, & SALADS

- 13 Vegetables and Legumes 256
- 14 Fruits 284
- 15 Soups, Salads, and Gelatins 310

## COMPLEX CARBOHYDRATES— CEREALS, FLOUR, BREADS

- 16 Cereal Grains and Pastas 326
- 17 Flours and Flour Mixtures 346

- 18 Starches and Sauces 369
- 19 Quick Breads 385
- 20 Yeast Breads 395

## DESSERTS—REFINED CARBOHYDRATES & FAT

- 21 Sweeteners 411
- 22 Fats and Oils 428
- 23 Cakes and Cookies 453
- 24 Pastries and Pies 471
- 25 Candy 489
- 26 Frozen Desserts 505

## WATER—BEVERAGES

- 27 Beverages 518

## PART IV FOOD INDUSTRY

- 28 Food Preservation 541
- 29 Government Food Regulations 555
- 30 Careers in Food and Nutrition 570

## APPENDIXES

- A Food Preparation Equipment A-1
- B Food Yields B-1
- C Substitution of Ingredients C-1
- D Flavorings and Seasonings D-1
- E Common Food Additives E-1
- F Answers to Multiple-Choice Questions F-1

GLOSSARY G-1

INDEX I-1

# Contents

**Preface xxiv**

**About the Author xxvii**

## **PART I FOOD SCIENCE AND NUTRITION**

### **Chapter 1 Food Selection 1**

#### **Sensory Criteria 1**

Sight 1

Odor 2

Classification of Odors 2

Detecting Odors 2

Taste 3

Mechanism of Taste 3

The Six Taste Stimuli 3

Taste Interactions 4

Factors Affecting Taste 4

Definition of Flavor 4

Touch 4

Hearing 6

#### **Nutritional Criteria 6**

Weight Management 6

Dietary Guidelines for Americans 6

ChooseMyPlate 6

SuperTracker 8

Previous Food Group Plans 8

Vegetarianism 8

Consumer Dietary Changes 9

Kcalories on Menus 9

Complementary and Integrative  
Medicine 9

Functional Foods 10

Nutrigenomics 11

#### **Cultural Criteria 11**

Ethnic Influences 11

Place of Birth 11

Geography and Climate 12

Cultural Influences on Manners 12

#### **Religious Criteria 12**

Buddhism 12

Hinduism 12

Seventh-Day Adventist Church 12

Church of Jesus Christ of Latter-Day Saints  
(Mormon Church) 12

Judaism 13

Islam 13

#### **Psychological and Sociological Criteria 14**

Bioengineering 14

History of Biotechnology 14

Foods Created with Biotechnology 14

Concerns about GMO Foods 15

Acceptance/Rejection of GM Foods 16

Organic Foods 16

Organic Certification 16

“Natural” Foods 17

Processed Foods 17

#### **Budgetary Criteria 17**

### **Chapter 2 Food Evaluation 20**

#### **Sensory (Subjective) Evaluation 20**

Two Types of Sensory Testing 20

Analytical (Effective) Tests 22

Affective (Acceptance or Preference)

Tests 22

Taste Panels 22

Sample Preparation 23

#### **Objective Evaluation 23**

Physical Tests 23

Chemical Tests 24

Electronic Noses 25

Comparison of Sensory and Objective

Evaluations 25

## Chapter 3 Chemistry of Food Composition 27

### Basic Food Chemistry: The Six Key Atoms (CHNOPS) 27

#### Water 28

- Water Content in Foods 29
- Composition of Water 29
- Measuring Heat Energy 30
- Specific Heat 30
- Freezing Point 30
- Melting Point 31
- Boiling Point 31
  - Elevation and Boiling Point 31
- Hard vs. Soft Water 31
- Functions of Water in Food 31
  - Heat Transfer: Moist-Heat Cooking Methods 32
- Solvent 32
  - Dispersions 32
  - Solutions 33
  - Colloidal Dispersions 33
  - Coarse Dispersions (Suspensions) 34
  - Dispersion Destabilization 34
- Chemical Reactions 34
  - Ionization 34
  - Changes in pH—Acids and Bases 34
  - Salt Formation 35
  - Hydrolysis 35
  - Carbon Dioxide Release 35
  - Food Preservation 35
  - Water Activity 35
  - Osmosis and Osmotic Pressure 36

#### Carbohydrates 36

- Foods High in Carbohydrates 36
- Composition of Carbohydrates 36
  - Monosaccharides 37
  - Disaccharides 38
  - Oligosaccharides 38
  - Polysaccharides 38
- Functions of Carbohydrates in Foods 43

#### Lipids (Fats) 43

- Foods High in Lipids 43
- Composition of Lipids 43
- Triglycerides 43
- Fatty Acids 43

- Fatty Acid Structure 43
- Fatty Acids in Foods 44
- Fatty Acid Nomenclature 45
- Phospholipids 45
  - Food Industry Uses 45
- Sterols 45
  - Plant Sterols 45
- Functions of Lipids in Foods 47

#### Proteins 47

- Protein Quality in Foods 47
- Composition of Proteins 47
- Amino Acids 48
- Functions of Proteins in Food 49
  - Hydration 49
  - Denaturation/Coagulation 49
  - Enzymatic Reactions 49
  - Buffering 51
  - Browning 51

#### Vitamins and Minerals 52

- Foods High in Vitamins and Minerals 52
- Composition of Vitamins and Minerals 53
- Functions of Vitamins and Minerals in  
Food 53
  - Enrichment and Fortification 53
  - Antioxidants and Their Food Industry  
Uses 53
  - Sodium and Its Food Industry Uses 53

#### Nonnutritive Food Components 53

- Food Additives 54
- Purposes of Food Additives 54
  - Additives that Improve Appeal 54
  - Additives that Extend Storage Life 56
  - Additives that Maximize Performance 56
  - Additives that Protect Nutrient Value 57
- Plant Compounds 57
  - Beneficial 57
  - Harmful 57
  - Caffeine 57

## PART II FOOD SERVICE

### Chapter 4 Food Safety 61

- What is a Foodborne Illness? 62
- What Causes Foodborne Illness? 62



## **Biological Hazards—Living Culprits 62**

- Bacteria: Number-One Cause of Foodborne Illness 63
  - Food Infections 63
  - Food Intoxication 64
  - Toxin-Mediated Infection 64

## **Bacterial Food Infections 65**

- Salmonella 65
- Listeria monocytogenes 65
- Yersinia enterocolitica 65
- Shigella 66

## **Bacterial Food Intoxications 66**

- Clostridium perfringens 66
- Staphylococcus aureus 66
- Clostridium botulinum 66

## **Bacterial Toxin-Mediated Infections 66**

- Escherichia coli 67
- Campylobacter jejuni 68
- Vibrio 68
  - Hepatitis A Virus 68

## **Molds 68**

## **Viruses 68**

- Norovirus 69

## **Parasites 69**

- Roundworms 69
- Protozoa 69

## **Prions—Mad Cow Disease 70**

## **New Virulent Biological Hazards 71**

- Advanced Techniques for Detecting Contamination 71

## **Chemical Hazards—Harmful Chemicals in Food 71**

- Seafood Toxins: Chemicals from Fish/Shellfish 72
  - Ciguatera Fish Poisoning 72
  - Histamine Food Poisoning 73
  - Puffer Fish Poisoning 73
  - Red Tide 73

## **Physical Hazards—Objects in Food 73**

## **Food Allergy, Intolerance, and Sensitivity 73**

- Allergic Reaction Prevention 73

- Labeling of Common Food Allergens 73
- Cross-Contamination 73

## **Preventing Foodborne Illness 74**

### **Prevention Factors Overview 74**

### **Personnel 74**

- Training 74
- Personal Hygiene Habits 74

### **Food Flow 75**

- Purchasing: Written Specifications 75
- Inspection 76
- Storage 76
- Temperature 76
- Proper Refrigerator and Freezer Use 77
- Storage Times 77

### **Vulnerable Foods 78**

- High-Risk Foods 78
- Foods with High Water Activity 78
- Foods with Low Acidity 78
- Exceptions to the High-Protein/Water/pH Rules 79
- Oxygen and Food 79

### **Preparation 79**

- Pre-preparation 79
- Cooking (Heating) 80
- Holding 80

## **Proper Use of Thermometers 82**

### **Types of Thermometers 82**

### **Testing Temperatures 82**

### **Care of Thermometers 83**

### **Calibration of Thermometers 83**

- Cooling 84
- Reheating 84
- Serving 84

### **Sanitation 84**

- Dishes 84
- Scheduling 85
- Equipment 85
- Facilities 85
- Pest Control 86

### **Food Safety Monitoring 86**

- Health Department Inspections 86
- HACCP 87
- HARPC 88
- Foodborne Illness Surveillance 88
- World Health Organization 88

## **Chapter 5 Food Preparation Basics 91**

### **Heating Foods 91**

Moist-Heat Preparation 92

### **Types of Moist-Heat Preparation 92**

Scalding 92

Poaching 92

Simmering 92

Stewing 92

Braising 92

Boiling 93

Steaming 93

Microwaving 93

Dry-Heat Preparation 93

### **Types of Dry-Heat Preparation 94**

Baking 94

Rack Position 94

Pan Color 94

Roasting 94

Broiling 94

Grilling 94

Barbecuing 94

Frying 95

Sautéing and Stir-Frying 95

Pan-Broiling and Pan-Frying 95

Deep-Frying 95

Types of Heat Transfer 95

Conduction 95

Convection 96

Radiation 96

Induction 96

Measuring Heat 96

### **Cutlery Techniques 97**

Handling Knives 97

Cutting Styles 98

### **Measuring Ingredients 101**

Measuring Weight vs. Volume 101

Using Scales 101

Metric vs. Nonmetric 101

Selecting the Right Measuring Utensil 101

Using an Accurate Measuring

Technique 101

Liquids 101

Eggs 102

Fat 102

Sugar 102

Flour 103

Other Ingredients and Substitutions 103

Approximating Food Requirements 103

### **Mixing Techniques 104**

Baked Products 104

### **Seasonings and Flavorings 104**

Types of Seasonings and Flavorings 104

Salt 104

Salt Substitutes 106

Pepper 106

Herbs and Spices 106

Flavor Enhancers 108

Oil Extracts 108

Marinades 108

Rubs and Pastes 108

Breadings 109

Batters 109

Condiments 110

Adding Seasonings and Flavorings  
to Food 110

How Much to Add? 110

When to Add? 110

Food Industry Uses 110

## **Chapter 6 Meal Management 113**

### **Food-Service Organization 113**

Commercial Food-Service

Organization 114

Escoffier's System of Organization  
via Stations 114

Administrative Positions 115

Hospital Food-Service Organization 115

### **Types of Meal Planning 116**

USDA Menu Patterns 116

Hospital Menu Patterns 117

Types of Menus 117

Cycle Menus 117

Nutrition 118

### **Purchasing 118**

Buyers 121

Food Stores and Vendors/Suppliers 121

Supermarkets 122

Warehouse Stores 122

- Co-ops 122
- Smaller Outlets 122
- Food-Service Vendors 122
- Cost Control 122**
  - Meats 122
  - Fish 122
  - Dairy 122
  - Bread/Grains 122
  - Fruits and Vegetables 122
  - Price Comparisons 122
- Reading Label Product Codes 123**
- Reducing Waste Saves Costs 123**
  - As Purchased vs. Edible Portion 123
  - Percentage Yield 123
  - Portion Control 123

### **Time Management 124**

- Estimating Time 124
- Efficient Meal Preparation 124
  - Recipes 124

### **Types of Meal Service 125**

- Russian Service 125
- French Service 127
- English Service 127
- American Service 127
- Family Service 127
- Buffet Service 127

### **Table Settings 127**

- Cover and Linens 127
- Flatware/Dinnerware/Glassware 127
- Accessories 127
- Centerpieces 128

## **PART III FOODS**

### **Chapter 7 Meat 131**

#### **Types Of Meats 131**

- Beef 131
- Veal 132
- Lamb and Mutton 132
- Pork 132

#### **Composition of Meats 132**

- Structure of Meat 132
  - Muscle Tissue 132

- Connective Tissue 133
- Adipose (Fatty) Tissue 133
- Bone 134
- Antibiotics and Hormones 134**
- Pigments 136**
  - Effect of Oxygen on Color 136
  - Effect of Heat on Color 137
- Extractives 137**

### **Purchasing Meats 137**

#### **Inspection 137**

#### **Grading 139**

- Quality 139
- Yield 140

#### **Tenderness of Meats 141**

- Natural Tenderizing 141
- Artificial Tenderizing 143

#### **Cuts of Meat 144**

- Terminology of Retail Cuts 144
- Beef Retail Cuts 144
- Veal Retail Cuts 146
- Pork Retail Cuts 146
- Lamb Retail Cuts 147
- Variety Meats 147
- Kosher Meats 149
- Halal Meats 149
- Organic Meats 149

#### **Processed Meats 149**

- Processing Methods 149
- Food Additives in Processed Meats 150
- Types of Processed Meat 152
- Mechanically Deboned Meat 152
- Restructured Meat 153

### **Preparation Of Meats 153**

#### **Changes during Heating 153**

- Tenderness and Juiciness 153
- Searing 153
- Flavor Changes 154
- Flavor Enhancements 154

#### **Determining Doneness 154**

- Internal Temperature 154
- Time/Weight Charts 155
- Color Changes 155
- Touch 156

#### **Dry-Heat Preparation 156**

- Roasting 156
- Broiling and Grilling 156

|                                  |            |   |            |
|----------------------------------|------------|---|------------|
| Pan-Broiling                     | 157        | Stewing                                     | 173        |
| Frying                           | 157        | Poaching                                    | 173        |
| Deep-Frying                      | 158        | Microwaving                                 | 173        |
| <b>Moist-Heat Preparation</b>    | <b>158</b> | <b>Storage of Poultry</b>                   | <b>174</b> |
| Braising                         | 158        | Refrigerated                                | 174        |
| Simmering or Stewing             | 158        | Frozen                                      | 174        |
| Steaming                         | 159        |   |            |
| Microwaving                      | 159        | <b>Chapter 9 Fish and Shellfish</b>         | <b>177</b> |
| Carving                          | 159        | <b>Classification of Fish and Shellfish</b> | <b>177</b> |
| <b>Storage of Meats</b>          | <b>159</b> | Vertebrate or Invertebrate                  | 177        |
| Refrigerated                     | 159        | Vertebrates                                 | 178        |
| Wrapping Meat                    | 159        | Invertebrates                               | 178        |
| Refrigeration Times              | 159        | Saltwater or Freshwater                     | 178        |
| Packaging                        | 160        | Lean or Fat                                 | 178        |
| Frozen                           | 160        | <b>Composition of Fish</b>                  | <b>178</b> |
| <b>Chapter 8 Poultry</b>         | <b>163</b> | Structure of Finfish                        | 178        |
| <b>Classification of Poultry</b> | <b>163</b> | Collagen                                    | 179        |
| <b>Composition of Poultry</b>    | <b>163</b> | Amino Acid Content                          | 179        |
| <b>Purchasing Poultry</b>        | <b>163</b> | Muscle Structure                            | 179        |
| Inspection                       | 163        | Pigments                                    | 179        |
| Grading                          | 165        | <b>Purchasing Fish and Shellfish</b>        | <b>180</b> |
| Types and Styles of Poultry      | 165        | Inspection/Grading                          | 181        |
| Processed Poultry                | 165        | Shellfish Certification                     | 181        |
| Labeling                         | 166        | Selection of Finfish                        | 181        |
| Standardized Poultry Buying      | 166        | Fresh and Frozen Fish                       | 181        |
| How Much to Buy                  | 167        | Canned Fish                                 | 184        |
| <b>Preparation of Poultry</b>    | <b>168</b> | Cured Fish                                  | 185        |
| Preparation Safety Tips          | 168        | Fabricated Fish                             | 185        |
| Thawing Frozen Poultry           | 168        | Caviar                                      | 186        |
| Stuffing                         | 168        | Selection of Shellfish                      | 186        |
| Brining                          | 168        | Purchasing Live Shellfish                   | 186        |
| Changes during Preparation       | 169        | Purchasing Processed Shellfish              | 187        |
| Determining Doneness             | 170        | Shucking Shellfish                          | 187        |
| Internal Temperature             | 170        | Oysters                                     | 187        |
| Color Change                     | 170        | Clams                                       | 188        |
| Touch                            | 170        | Scallops                                    | 188        |
| Time/Weight Charts               | 170        | Mussels                                     | 188        |
| Dry-Heat Preparation             | 170        | Abalone                                     | 188        |
| Roasting or Baking               | 170        | Lobsters                                    | 188        |
| Broiling or Grilling             | 172        | Shrimp                                      | 189        |
| Frying                           | 173        | Crab  | 189        |
| Moist-Heat Preparation           | 173        | Crayfish                                    | 190        |
| Braising                         | 173        | <b>Preparation of Fish and Shellfish</b>    | <b>190</b> |
|                                  |            | Dry-Heat Preparation                        | 190        |

|   |            |
|---|------------|
| Baking                                      | 190        |
| Broiling                                    | 191        |
| Grilling                                    | 191        |
| Frying                                      | 191        |
| Moist-Heat Preparation                      | 191        |
| Poaching                                    | 191        |
| Simmering                                   | 192        |
| Steaming                                    | 192        |
| Microwaving                                 | 192        |
| <b>Raw Fish Preparation</b>                 | <b>193</b> |
| Sashimi                                     | 193        |
| Sushi                                       | 193        |
| Ceviche                                     | 193        |
| Food Safety Concerns                        | 193        |
| <b>Storage of Fish and Shellfish</b>        | <b>193</b> |
| <b>Fresh Finfish</b>                        | <b>194</b> |
| Refrigerated                                | 194        |
| Spoilage Factors                            | 194        |
| Storing Caviar                              | 194        |
| <b>Fresh Shellfish</b>                      | <b>194</b> |
| <b>Frozen</b>                               | <b>194</b> |
| Thawing                                     | 194        |
| <b>Canned and Cured</b>                     | <b>194</b> |
| <b>Chapter 10 Milk</b>                      | <b>197</b> |
| <b>Functions of Milk in Foods</b>           | <b>198</b> |
| <b>Composition of Milk</b>                  | <b>198</b> |
| <b>Nutrients</b>                            | <b>198</b> |
| Carbohydrate                                | 198        |
| Protein                                     | 199        |
| Fat   | 199        |
| Vitamins                                    | 200        |
| Minerals                                    | 200        |
| <b>Color Compounds</b>                      | <b>200</b> |
| <b>Food Additives</b>                       | <b>201</b> |
| <b>Purchasing Milk</b>                      | <b>202</b> |
| <b>Grades</b>                               | <b>202</b> |
| <b>Pasteurization</b>                       | <b>202</b> |
| Ultrapasteurization                         | 202        |
| Ultrahigh-Temperature Processing            | 202        |
| <b>Homogenization</b>                       | <b>203</b> |
| <b>Types of Milk</b>                        | <b>204</b> |
| <b>Fresh Fluid Cow Milks</b>                | <b>204</b> |
| Whole Milk                                  | 204        |
| Reduced-Fat and Low-Fat Milks               | 204        |
| Fat-Free or Nonfat Milk                     | 204        |
| <b>Fresh Fluid Milks from Other Animals</b> | <b>204</b> |
| <b>Flavored Fluid Milks</b>                 | <b>204</b> |
| Chocolate Milk                              | 205        |
| Eggnog                                      | 205        |
| <b>Ultrahigh-Temperature Milk (UHT)</b>     | <b>205</b> |
| <b>Nutritionally Altered Fluid Milks</b>    | <b>205</b> |
| Imitation Milk                              | 206        |
| Filled Milk                                 | 206        |
| Low-Sodium Milk                             | 206        |
| Reduced-Lactose Milk                        | 206        |
| <b>Plant-Based “Milks”</b>                  | <b>206</b> |
| Soy Milk                                    | 206        |
| Rice Milk                                   | 206        |
| Almond Milk                                 | 206        |
| Nut Milks                                   | 207        |
| Hemp Milk                                   | 207        |
| Grain Milk                                  | 207        |
| Coconut Milk                                | 207        |
| <b>Canned Fluid Milks</b>                   | <b>207</b> |
| Whole Milk                                  | 207        |
| Evaporated Milk                             | 207        |
| Sweetened Condensed Milk                    | 208        |
| <b>Dry Milk</b>                             | <b>208</b> |
| Nonfat Dry Milk                             | 208        |
| Instant Milk                                | 208        |
| <b>Cultured Milk Products</b>               | <b>208</b> |
| Cultures Added to Milk                      | 208        |
| Buttermilk                                  | 209        |
| Yogurt                                      | 210        |
| Functional Foods—Probiotics                 | 211        |
| Acidophilus Milk                            | 211        |
| Kefir                                       | 211        |
| Sour Cream                                  | 211        |
| <b>Creams and Substitutes</b>               | <b>212</b> |
| Cream                                       | 212        |
| Cream Substitutes                           | 212        |
| <b>Milk Products in Food Preparation</b>    | <b>212</b> |
| <b>Flavor Changes</b>                       | <b>212</b> |
| <b>Coagulation and Precipitation</b>        | <b>212</b> |
| Heat  | 212        |
| Acid  | 212        |
| Enzymes                                     | 213        |
| Salts                                       | 213        |
| <b>Whipped Milk Products</b>                | <b>213</b> |

Whipped Cream 213  
Whipped Evaporated Milk 214  
Whipped Reconstituted Nonfat Dry  
Milk 215

### **Storage of Milk Products 215**

Refrigerated 215  
Dry Storage 215

## **Chapter 11 Cheese 218**

### **Classification of Cheeses 218**

Place of Origin 219  
Moisture Content 219

### **Cheese Production 219**

Milk Selection 221  
Coagulation 221  
    Enzyme Coagulation 221  
    Acid Coagulation 223  
Curd Treatment 223  
Curing and Ripening 224  
Whey and Whey Products 226  
    Whey Cheeses 228  
    Dry Whey 228  
    Modified Whey Products 228  
Process (Processed) Cheeses 228  
    Process Cheese 228  
    Cold-Pack Cheese 228  
    Process Cheese Food 229  
    Process Cheese Spread 229  
    Imitation Cheese 229  
    Tofu and Other Nondairy Cheeses 229  
Food Additives in Cheese 229

### **Purchasing Cheese 229**

Grading 229  
Forms of Cheese 230

### **Food Preparation with Cheese 230**

Selecting a Cheese 230  
    Shreddability 230  
    Meltability 230  
    Oiling Off 231  
    Blistering 231  
    Browning 231  
    Stretchability 231  
Temperatures 231  
Cutting Cheese 232

### **Storage of Cheese 232**

Dry Storage 232  
Refrigeration 232  
Frozen 233

## **Chapter 12 Eggs 236**

### **Composition of Eggs 236**

Yolk 236  
Albumen 237  
Shell Membranes 237  
Air Cell 237  
Shell 238

### **Purchasing Eggs 238**

Inspection 238  
    Eggs Failing USDA Inspection 238  
Grading 238  
    Grading Methods 238  
Sizing 240  
Egg Substitutes 240  
Value-Added Eggs 240

### **Types of Eggs 241**

### **Functions of Eggs in Foods 241**

Emulsifying 241  
Binding 241  
Foaming 241  
    Beating Technique 243  
    Temperature 243  
    Bowl Selection 244  
    Separation of Eggs 244  
    Additives 244  
Interfering 244  
Clarifying 244  
Color 244

### **Preparation of Eggs 244**

Changes in Prepared Eggs 245  
    Effects of Temperature and Time 245  
    Effects of Added Ingredients 245  
    Color Changes 245  
Dry-Heat Preparation 246  
    Frying 246  
    Baking 247  
Moist-Heat Preparation 248  
    Hard or Soft “Boiling” 248  
    Coddling 249  
    Poaching 249

Custards 250  
Microwaving 250

### **Storage of Eggs 251**

#### **Refrigerator 251**

Whole Eggs 251  
Storage Eggs 251  
Pasteurized Eggs 251

#### **Frozen 251**

#### **Dried 252**

Rehydrating Dried Eggs 252

#### **Safety Tips 252**

Purchase 253  
Preparation 253  
Consumption 253  
Storage 253

## **Chapter 13 Vegetables and Legumes 256**

### **Classification of Vegetables 256**

### **Composition of Vegetables 256**

#### **Structure of Plant Cells 256**

Cell Wall 256  
Storage Structures in Parenchyma Cells 257  
Intercellular Air Spaces 258

#### **Plant Pigments 258**

Carotenoids 258  
Chlorophyll 258  
Flavonoids 259

#### **Plants as Functional Foods 259**

#### **Additives 261**

### **Purchasing Vegetables 263**

#### **Grading Vegetables 263**

#### **Selecting Vegetables 263**

Artichoke 263  
Asparagus 266  
Beans (Green Snap, Green, Wax, and Yellow Wax-Pod Beans) 266  
Beets 266  
Broccoli 266  
Brussels Sprouts 266  
Cabbage 266  
Carrots 266  
Cauliflower 266  
Celery 266

Corn 266  
Cucumbers 266  
Eggplant 267  
Exotic Vegetables 267  
Garlic 267  
Ginger 268  
Greens 268  
Leeks 268  
Lettuce 268  
Mushrooms 268  
Okra 269  
Onions 269  
Parsley 270  
Parsnips 270  
Peas 270  
Peppers, Hot 270  
Peppers, Sweet 270  
Potatoes 270  
Radishes 271  
Rutabagas 271  
Spinach 271  
Sprouts 271  
Squash 272  
Sweet Potatoes 272  
Tomatoes 273  
Turnips 273

### **Legumes 273**

#### **Textured Vegetable Protein 274**

#### **Meat Analogs 274**

#### **Tofu 274**

#### **Fermented Soybean Foods 274**

### **Preparation of Vegetables 275**

#### **General Guidelines 275**

#### **Changes During Heating 275**

Texture 275  
Flavor 275  
Odor 276  
Color 276  
Nutrient Retention 277

#### **Dry-Heat Preparation 277**

Baking 277  
Roasting 278  
Frying 278

#### **Moist-Heat Preparation 278**

Simmering 278

- Steaming 278
- Braising 279
- Microwaving 279
- Preparing Legumes 279
- Preparing Sprouts 280**
  - Growing Sprouts 280
  - Storing Sprouts 280
- Storage of Vegetables 280**
- Refrigerated 281**
  - Special Storage Requirements 281
  - Maintaining Moisture 281
- Freezing 281**
- Dry Storage 281**
  - Storing Potatoes 281
- Controlled-Atmosphere Storage 281**

## **Chapter 14 Fruits 284**

- Classification of Fruits 284**
- Classification Exceptions 285
- Composition of Fruits 285**
- Organic Acids 285
- Acidity of Fruits 285
- Pectic Substances 285**
  - Use of Pectin by the Food Industry 286
  - Pectin Formation in Ripening Fruit 286
  - Pectic Substances and Juice
    - Cloudiness 286
- Phenolic Compounds 286**
  - Phenolic Compounds and Enzymatic Browning 286
- Fruits as Functional Foods 287**
- Food Additives in Fruits 288**
- Purchasing Fruits 289**
- Grading Fruit 289**
- Selecting Fruits 290**
  - Apples 290
  - Apricots 290
  - Avocados 290
  - Bananas 291
  - Berries 291
  - Cherries 292
  - Dates 292
  - Figs 292
  - Grapefruit 293
  - Grapes 293

- Guavas 293
- Kiwifruit 293
- Kumquats 293
- Lemons 293
- Limes 293
- Mandarins 293
- Mangoes 294
- Melons 294
- Nectarines 294
- Olives 295
- Oranges 295
- Papayas 296
- Peaches 296
- Pears 296
- Persimmons 296
- Pineapple 296
- Plums 297
- Pomegranates 298
- Rhubarb 298
- Tangerines—see Mandarins 298
- Tropical Fruits 298
- Superfruits 298
- Processed Fruits 299**
  - Canned 299
  - Frozen 300
  - Dried 300
- Fruit Juices 300**
  - Fruit/Vegetable Juice Processing 300
- Preparation of Fruits 302**
- Limiting Enzymatic Browning 302**
  - Denaturing Enzymes 302
  - Reducing pH 302
  - Lowering Temperature 302
  - Coating Fruits with Sugar or Water 302
  - Adding Antioxidants 302
- Changes during Ripening and Heating 302**
  - Color 302
  - Texture 303
  - Flavor 304
- Dry-Heat Preparation 304**
  - Baking 304
  - Broiling 304
  - Frying/Sautéing 304
- Moist-Heat Preparation 304**
  - Stewing/Poaching 304



- Applesauce Preparation 305
- Preparing Dried Fruit 305
- Fruit Spreads 305**
  - Types of Fruit Spreads 305
  - Ingredients 305
  - Preparing Fruit Spreads 306

### **Storage of Fruits 307**

- Storing Fresh Fruit 307
- Storing Canned Fruit 307
- Olives 307

## **Chapter 15 Soups, Salads, and Gelatins 310**

### **Soups 310**

- Types of Soups 310
- Stocks 311
  - White and Brown Stocks 311
  - Water: The Main Ingredient 311
  - Flavoring Ingredients 312
  - Meat Stocks 312
  - Poultry Stocks 312
  - Fish Stocks 312
  - Vegetable Stocks 313
  - Storage of Soup Stocks 313

### **Clear and Thin Soups 313**

- Bouillon 313
- Consommé 313
- Thin Soups 313

### **Thickened Soups 313**

- Cream Soups 314

### **Salads 315**

- Salad Ingredients 316
  - Garnishes 316
  - Toasting Nuts 316
- Principles of Salad Preparation 316
  - Leafy Green Salads 316
  - Vegetable Salads 318
  - Fruit Salads 318
  - Protein Salads 319
  - Pasta/Grain Salads 319

### **Salad Dressings 319**

- Oil and Vinegar Dressings 320
- Emulsified Dressings 320
- Other Dressings 320
- Adding Dressings to Salads 321

### **Gelatins 321**

- What Is Gelatin? 321
- Is Gelatin Nutritious? 321
- Preparation of a Gel 321
- Phases of Gel Formation 321
  - Phase 1—Hydration 321
  - Phase 2—Dispersion 321
  - Phase 3—Gelation 322
- Unmolding a Mold 322
- Factors Influencing Gel Formation 322
  - Gelatin Concentration 322
  - Temperature 322
  - Added Ingredients 323
  - Whipping 323
- Storage of Gelatin 323

## **Chapter 16 Cereal Grains and Pastas 326**

### **Composition of Cereal Grains 327**

- Structure 327
  - Husk 327
  - Bran 327
  - Endosperm 327
  - Germ 328
- Food Additives in Grain Products 328

### **Uses Of Cereal Grains 329**

- Flour 329
- Pasta 329
- Breakfast Cereal 329
- Alcoholic Beverages 329
- Animal Feeds 329

### **General Types of Cereal Grains 329**

### **Cereal Grains Containing Gluten 330**

- Wheat 330
  - Classification of Wheat 330
  - Forms of Wheat 331
- Ancient Wheat Grains 331
- Barley 331
  - Forms of Barley 331
- Oats 332
  - Forms of Oats 332
- Rye 332
- Triticale 333

## **Gluten-Free Cereal Grains 334**

- Amaranth 334
- Buckwheat 334
- Chia Seeds 334
- Corn 334
  - Classification of Corn 334
  - Forms of Corn 335
- Indian Rice Grass 336
- Millet 336
- Quinoa 336
- Rice 336
  - Classification of Rice 336
  - Forms of Rice 337
- Sorghum 337
- Teff 337

## **Preparation of Cereal Grains 338**

- Moist-Heat Preparation: Boiling/  
Simmering 338
  - Preparation 338
  - Cooking the Grain 338
  - Determining Doneness 339
  - Standing Time 339
- Sautéing and Baking 339
- Microwaving 339

## **Storage of Cereal Grains 339**

- Dry 339
- Refrigerated 340
- Frozen 340

## **Pastas 340**

- Types of Pasta 340

## **Preparation of Pasta 341**

- Moist-Heat Preparation 341
- Microwaving 342

## **Storage of Pasta 342**

## **Chapter 17 Flours and Flour Mixtures 346**

### **FLOURS 347**

- Starch 347
- Gluten 347
  - Purpose of Gluten 347
  - Steps to Gluten Formation 348
  - Dried Gluten 349
- Cereal-Grain Food Sensitivities 350

- Baker's Asthma 350
- Wheat Allergy 350
- Celiac Disease 350
- Nonceliac Gluten Sensitivity (NCGS) 350

### **What Does "Gluten-Free" Mean? 350**

#### **Milling 350**

- Five Steps of Milling 351
- Wet Milling 352

#### **Wheat Flour Classifications 352**

- Percent Protein Content 352
- Mineral Content 352

#### **Types of Wheat Flour 352**

- Whole-Wheat Flour 352
- Bread Flour 352
- White Flour 353
- Graham Flour 353
- Ancient Grain Flours 353
- High-Gluten Flour 353

#### **Types of Nonwheat Grain Flours**

##### **Containing Gluten 354**

- Rye Flour 354
- Triticale Flour 354

##### **Types of Gluten-Free Grain Flours 354**

- Amaranth 354
- Buckwheat Flour 354
- Cornmeal Flour 354
- Rice Flour 355
- Sorghum Flour 355
- Gluten-Free Flour 355

##### **Types of Nongrain, Gluten-Free Flours 355**

- Tuber-Based: Potato Flour 355
- Legume-Based 355
- Nut-Based 355

##### **Treated Wheat Flours 355**

- Aged Flour 355
- Bleached Flour 355
- Phosphated Flour 355
- Self-Rising Flour 356
- Instant or Agglomerated Flour 356
- Enriched Flour 356

### **Flour Mixture Ingredients 356**

#### **Leavening Agents 356**

- Air and Steam 356
- Yeast 356
- Bacteria 358

|  |            |
|--|------------|
| Baking Soda                                | 358        |
| Potassium Bicarbonate                      | 359        |
| Baking Powder                              | 359        |
| Too Much/Too Little Leavening              | 360        |
| Too Much/Too Little Flour                  | 360        |
| <b>Sugar</b>                               | <b>360</b> |
| Functions of Sugar                         | 360        |
| Types of Sugar                             | 360        |
| Too Much/Too Little Sugar                  | 360        |
| <b>Salt</b>                                | <b>361</b> |
| Salt Controls Yeast Growth                 | 361        |
| Too Much/Too Little Salt                   | 361        |
| <b>Flavorings</b>                          | <b>361</b> |
| <b>Liquid</b>                              | <b>361</b> |
| Milk                                       | 361        |
| Too Much/Too Little Liquid                 | 361        |
| <b>Fat</b>                                 | <b>361</b> |
| Functions of Fat                           | 362        |
| Types of Fat Used in Baked Goods           | 362        |
| Temperature of Fat                         | 363        |
| Lower-Fat Alternatives                     | 363        |
| Too Much/Too Little Fat                    | 363        |
| <b>Eggs</b>                                | <b>363</b> |
| Too Much/Too Little Egg                    | 363        |
| <b>Commercial Additives</b>                | <b>363</b> |
| Aging or Maturing Agents                   | 363        |
| Dough Conditioners                         | 363        |
| <b>Food Additives in Flours</b>            | <b>364</b> |
| <b>Preparation of Baked Goods</b>          | <b>365</b> |
| <b>Doughs and Batters</b>                  | <b>365</b> |
| Doughs                                     | 365        |
| Batters                                    | 365        |
| Changes during Heating                     | 365        |
| High-Altitude Adjustments                  | 366        |
| <b>Storage of Flour And Flour Mixtures</b> | <b>366</b> |
| Dry Storage                                | 366        |
| Frozen                                     | 366        |
| <b>Chapter 18 Starches and Sauces</b>      | <b>369</b> |
| <b>Starch Characteristics</b>              | <b>369</b> |
| Sources of Starch                          | 369        |
| Cornstarch                                 | 370        |
| Starch in Food Products                    | 370        |
| Thickening Agent                           | 370        |
| Edible Films                               | 370        |
| Dextrose                                   | 370        |
| Starch Syrups                              | 371        |
| <b>Starch Structure</b>                    | <b>371</b> |
| <b>Starch Transformations</b>              | <b>372</b> |
| Gelatinization                             | 372        |
| Factors Influencing Gelatinization         | 372        |
| Gel Formation                              | 373        |
| Retrogradation                             | 374        |
| Dextrinization                             | 374        |
| Instant or Pregelatinized Starches         | 375        |
| Resistant Starches (RS)                    | 375        |
| RS4 Modified (Chemically) Starches         | 375        |
| <b>Sauces</b>                              | <b>376</b> |
| Functions of Sauces in Foods               | 376        |
| Types of Sauces                            | 376        |
| Mother Sauces                              | 376        |
| Small Sauces                               | 376        |
| Preparation of Thickened Sauces            | 377        |
| Ingredients of Thickened Sauces            | 377        |
| Preparing Thickeners                       | 378        |
| Preparing a Sauce from a Roux              | 379        |
| Preventing Lumps                           | 379        |
| Preparation of Unthickened Sauces          | 380        |
| Gravy                                      | 380        |
| Hollandaise Sauce                          | 381        |
| Barbecue Sauce                             | 381        |
| Butter Sauce                               | 381        |
| Fruit Sauce                                | 381        |
| Tartar Sauce                               | 381        |
| Tomato Sauce                               | 382        |
| <b>Storage of Starches And Sauces</b>      | <b>382</b> |
| <b>Chapter 19 Quick Breads</b>             | <b>385</b> |
| <b>Preparation of Quick Breads</b>         | <b>385</b> |
| The Muffin Method                          | 386        |
| Additives Used in Quick Breads             | 386        |
| <b>Varieties of Quick Breads</b>           | <b>386</b> |
| Pour Batters                               | 386        |
| Pancakes                                   | 386        |
| Crêpes                                     | 386        |
| Waffles                                    | 387        |
| Popovers                                   | 387        |
| Drop Batters                               | 387        |

Muffins 388  
Muffin Breads 389  
Coffee Cakes 390  
Dumplings 390  
**Doughs 390**  
Unleavened Breads 390  
Biscuits 391  
Scones 392  
Crackers 392

## **Chapter 20 Yeast Breads 395**

### **Preparation of Yeast Breads 395**

Ingredients 395  
Food Additives in Baked Products 396  
Mixing Methods 397  
Straight Dough Method 398  
Sponge Method 398  
Batter Method 398  
Rapid Mix 398  
Kneading 398  
Proofing: Fermentation Causes the Dough to Rise 399  
Changes during Fermentation 400  
Optimal Fermentation Conditions 400  
Avoid Overfermentation 400  
Punching Down and Second Proofing 401  
Shaping 401  
Selecting a Baking Pan 402  
Decorating 402  
Baking 402  
Changes during Baking 402  
Crumb Development 403  
Problems with Texture 403  
Testing for Doneness 403  
Microwave Preparation 404  
High-Altitude Adjustments 405

### **Types of Yeast Breads 405**

**Loaf Breads 405**  
Wheat (White) Bread 405  
Whole-Wheat Bread 406  
Sourdough Bread 406  
Malt Breads 406  
Specialty Breads 406  
**Rolls 406**  
Pita Bread 406  
Bagels 407

English Muffins 407  
Pizza Crust 408  
Pretzels and Bread Sticks 408  
Raised Doughnuts 408

### **Storage of Yeast Breads 408**

**Fresh 408**  
Staling 408  
Preventing Staling 408  
Fresh Bread Additives 408  
**Refrigerated 408**  
Frozen 408

## **Chapter 21 Sweeteners 411**

### **Natural Sweeteners 412**

**Sugars 413**  
Sucrose 413  
Lactose 414  
Maltose 414  
Glucose 415  
Fructose 415  
Syrups 415  
Corn Syrup 415  
High-Fructose Corn Syrup 416  
Honey 416  
Molasses 417  
Maple Syrup 417  
Agave Syrup 418  
Invert Sugar 418  
**Sugar Alcohols 418**  
Sugar Alcohols in Foods 418  
Problems with Sugar Alcohols 419

### **Nonnutritive Sweeteners 419**

**Use in Foods and Beverages 419**

### **Safety 419**

### **Food Functions 421**

Saccharin 421  
Aspartame 421  
Acesulfame-K 421  
Sucralose 421  
Neotame 422  
Stevia and Its Derivatives 422  
Luo Han Guo 422  
Other Nonnutritive Sweeteners 423

### **Functions of Sugars In Foods 423**

**Sweetness 423**

Solubility 424  
Crystallization 424  
Browning Reactions 424  
Caramelization 425  
Moisture Absorption (Hygroscopicity) 425  
Texture 425  
Fermentation 425  
Preservation 425  
Leavening 425  
Other Uses 425

## Chapter 22 Fats and Oils 428

### Functions of Fats In Food 429

Heat Transfer 429  
Shortening Power 429  
Emulsions 430  
    Emulsifiers 430  
    Stability of Emulsions 431  
Melting Point 431  
    Degree of Saturation 431  
    Length of the Fatty Acids 432  
    Cis–Trans Configuration 432  
    Crystalline Structure 433

Plasticity 433  
Solubility 433  
Flavor 433  
Texture 433  
Appearance 433  
Satiety or Feeling Full 434

### Types of Fats 434

Butter 434  
Margarine 434  
    Composition of Margarine 434  
    Types of Margarine 435  
Shortenings 436  
Oils 436  
    Oil Production 437  
    Types of Oils 439  
    Winterized Oils 440  
    Hydrogenated Oils 440

Lard/Tallow/Suet 441  
    Interesterification 441

Cocoa Butter 441

### Fat Replacers 441

Types of Fat Replacers 441  
Composition of Fat Replacers 441

Carbohydrate-Based Fat Replacers 441  
Protein-Based Fat Replacers 441  
Lipid-Based Fat Replacers 441

### Food Preparation with Fats 443

Selection and Care of Frying Fats 443  
    Fats Suitable for Frying 443  
    Smoke Point 443  
    Flash Point and Fire Point 443  
    Controlling the Temperature of Frying Fats 444  
    Recommended Equipment 444  
    Optimal Frying Conditions 444

### Lower-Fat Preparation Techniques 445

Fats Preferred for Health 445  
Reducing Fat by Healthy Methods 445  
Modifying Recipes to Reduce Fat 445  
Pretreatments to Reduce Absorbed Oil 446

### Storage of Fats 446

Rancidity 447  
    Types of Rancidity 447  
    Flavor Reversion 448  
    Preventing Rancidity 448

## Chapter 23 Cakes and Cookies 453

### Types of Cakes 453

Shortened Cakes 453  
    Bundt Cake 454  
    Butter Cake 454  
    Carrot Cake 454  
    Cheesecake 454  
    Ciambellone 454  
    Coffee Cake 454  
    Cupcake 454  
    Devil's Food Cake 454  
    Fruitcake 454  
    German Chocolate Cake 454  
    Ice Cream 455  
    Mooncake 455  
    Muffin 455  
    Pound Cake 455  
    Upside-Down Cake 455  
Unshortened Cakes 455  
    Angel Food Cake 455  
    Boston Cream Pie 455  
    Dacquoise (da-kwoz) 455  
    Génoise (zh-eh-nwoz) 455  
    Meringue (mer-rang) 455

|  |            |   |            |
|--|------------|---|------------|
| Petit Four                                     | 455        | Cialde (chee-al-day)                        | 465        |
| Roulade (roo-lahd)                             | 455        | Florentines                                 | 465        |
| Tiramisu (teer-a-me-sue)                       | 455        | Fortune Cookies                             | 465        |
| <b>Chiffon Cakes</b>                           | <b>456</b> | Macarons                                    | 465        |
| <b>Preparation of Cakes</b>                    | <b>456</b> | Macarons                                    | 465        |
| <b>Ingredients</b>                             | <b>456</b> | Madeleines                                  | 465        |
| Flour  | 456        | Meringues                                   | 465        |
| Sugar  | 456        | Wafers                                      | 465        |
| Fats   | 457        | <b>Pressed Cookies</b>                      | <b>466</b> |
| Eggs   | 457        | Ladyfingers                                 | 466        |
| Milk   | 457        | Russian Tea Cookies (Mexican Wedding Cakes) | 466        |
| Leavening Agent                                | 457        | <b>Molded Cookies</b>                       | <b>466</b> |
| Additional Ingredients                         | 457        | Almond Cookies                              | 466        |
| Other Factors                                  | 458        | Biscotti di Prato                           | 466        |
| <b>Preparing Shortened Cakes</b>               | <b>458</b> | Peanut Butter Cookies                       | 466        |
| Selection and Preparation of Pans              | 458        | <b>Rolled Cookies</b>                       | <b>466</b> |
| Temperature/Timing                             | 459        | Butter Cookies                              | 466        |
| Changes during Baking                          | 459        | Cannoli Shell                               | 466        |
| Testing for Doneness                           | 460        | Gingerbread                                 | 466        |
| Cooling  | 460        | Linzer Cookies                              | 466        |
| High-Altitude Adjustments                      | 461        | Mandelbrot                                  | 466        |
| Microwave Preparation                          | 461        | Shortbread                                  | 466        |
| <b>Preparing Unshortened and Chiffon Cakes</b> | <b>461</b> | Sugar                                       | 466        |
| Angel Food Cake                                | 461        | <b>Icebox/Refrigerator Cookies</b>          | <b>466</b> |
| Sponge Cake                                    | 462        | <b>Cookies as Functional Foods</b>          | <b>466</b> |
| Chiffon Cake                                   | 462        | <b>Preparation of Cookies</b>               | <b>467</b> |
| Selection and Preparation of Pans              | 462        | <b>Ingredients and Mixing Methods</b>       | <b>467</b> |
| Temperature/Timing                             | 463        | Food Additives in Cookies                   | 467        |
| Testing for Doneness                           | 463        | <b>Baking Cookies</b>                       | <b>467</b> |
| <b>Frostings/Icings</b>                        | <b>463</b> | Selection and Preparation of Pans           | 467        |
| Flat Frostings                                 | 463        | Temperature/Timing                          | 468        |
| Decorating Frosting                            | 463        | Testing for Doneness                        | 468        |
| Cooked Frosting                                | 463        | High-Altitude Adjustments                   | 468        |
| Whipped Cream Frosting                         | 463        | Microwave Preparation                       | 468        |
| Ganache  | 463        | <b>Storage of Cookies</b>                   | <b>468</b> |
| Garnishes                                      | 464        | <b>Chapter 24 Pastries and Pies</b>         | <b>471</b> |
| <b>Storage of Cakes</b>                        | <b>464</b> | <b>Types of Pastry</b>                      | <b>471</b> |
| <b>Types of Cookies</b>                        | <b>464</b> | Pastry Classification                       | 471        |
| Bar Cookies                                    | 465        | Nonlaminated Pastries                       | 471        |
| Brownies                                       | 465        | Plain Pastry                                | 471        |
| Lemon Bars                                     | 465        | Brioche Pastry                              | 472        |
| <b>Dropped Cookies</b>                         | <b>465</b> | Choux Pastry                                | 472        |
| Chocolate Chip Cookies                         | 465        | <b>Laminated Pastries</b>                   | <b>473</b> |

Puff Pastry 473  
Quick (Blitz) Pastry 473  
Phyllo (Filo) Pastry 473  
Croissant Pastry 473  
Danish Pastry 473

## **Preparation of Pastry 474**

### **Ingredients of Pastry 474**

Flour 475  
Fat 475  
Liquid 476  
Eggs 477  
Salt 477  
Sugar 477  
Flavorings 477  
Thickeners (for Fillings) 477

### **Mixing Methods 478**

Plain (Pie) Pastry 478  
Puff Pastry 478

### **Rolling 479**

Chilling the Dough 479  
Rolling Surface 480  
General Technique 480  
Rolling Plain Pastry 480  
Rolling Puff Pastry 481

### **Fillings 483**

Fruit Fillings 483  
Cream Fillings 483  
Custard Fillings 483  
Chiffon Pies 484  
Meringue Pies 484  
Pastry Fillings 484

### **Toppings 484**

Glazes 484  
Crumb Toppings 484

### **Baking 485**

### **Pan Selection and Preparation 485**

Temperature and Timing 485  
Testing for Doneness 485

## **Storage of Pastry 485**

## **Chapter 25 Candy 489**

### **Classification of Candies 489**

Syrup Phase versus Fat Phase 489  
Crystalline versus Noncrystalline  
(Amorphous) 490

## **Preparation of Candy 490**

### **Confectionery Preparation Overview 490**

### **Crystalline Candies 491**

Candies Start with a Syrup Solution 491  
Heating the Syrup 491  
Cooling and Beating 493  
Types of Crystalline Candies 494

### **Noncrystalline Candies 495**

Concentrating the Sugar Solution 495  
Interfering Agents 495  
Types of Noncrystalline Candies 495

### **Food Additives in Candy 496**

## **Chocolate 496**

### **Cacao Tree 496**

### **History 496**

### **Chocolate Production 497**

Cocoa Beans Produce Chocolate Liquor 497

### **Chocolate Liquor 498**

Conching 498  
Tempering 498  
Factors Affecting Tempering 499

### **Types of Chocolate Products 501**

Baking Chocolate 501  
Cocoa 501  
Semisweet or Sweet Chocolate 501  
Milk Chocolate 501  
Imitation Chocolate 501  
White Chocolate 501  
Functional Chocolate 501

## **Storage of Candy 502**

### **Shelf Life of Chocolate 502**

## **Chapter 26 Frozen Desserts 505**

### **Types of Frozen Desserts 505**

### **Ice Cream 506**

Ice Cream Ingredients 506  
Low-Fat Ice Cream 507  
Ice Cream as a Functional Food 507

### **Imitation Ice Cream 507**

### **Gelato 507**

### **Frozen Yogurt 507**

### **Sherbet 507**

### **Sorbet 508**

### **Water Ices 508**

Popsicles 508  
Granitas and Granités 508

|  |            |                              |            |
|--|------------|------------------------------|------------|
| Frappés                                  | 508        | Roasting                     | 524        |
| Still-Frozen Desserts                    | 508        | Grinding                     | 524        |
| <b>Preparation of Frozen Desserts</b>    | <b>508</b> | Decaffeination               | 524        |
| Factors Affecting Quality                | 508        | Instant Coffee               | 524        |
| Flavor                                   | 508        | <b>Composition of Coffee</b> | <b>524</b> |
| Texture                                  | 508        | Volatile Compounds           | 524        |
| Body                                     | 510        | Bitter Substances            | 525        |
| <b>Mixing and Freezing</b>               | <b>511</b> | Methylxanthines              | 525        |
| Ice Cream                                | 511        | <b>Types of Coffee</b>       | <b>525</b> |
| Frozen Yogurt                            | 513        | Types of Beans               | 525        |
| Sherbet                                  | 513        | Types of Processing          | 525        |
| Sorbet                                   | 513        | Types of Ingredients         | 526        |
| Water Ices                               | 514        | <b>Preparation of Coffee</b> | <b>526</b> |
| Still-Frozen Desserts                    | 514        | Coffee Freshness             | 526        |
| <b>Food Additives in Frozen Desserts</b> | <b>514</b> | Water-to-Coffee Ratio        | 526        |
| <b>Storage of Frozen Desserts</b>        | <b>514</b> | Water Type                   | 526        |
| Texture Changes                          | 514        | Water Temperature            | 526        |
| Scooping Frozen Desserts                 | 515        | Brewing Time                 | 526        |
|  |            | Brewing Equipment            | 527        |
|  |            | Holding Time                 | 527        |
| <b>Chapter 27 Beverages</b>              | <b>518</b> | <b>Storage of Coffee</b>     | <b>527</b> |
| <b>Water</b>                             | <b>518</b> | <b>Tea</b>                   | <b>528</b> |
| Bottled Water                            | 518        | Tea Processing               | 528        |
| Sources of Water                         | 519        | Withering                    | 528        |
| <b>Water Treatment Methods</b>           | <b>519</b> | Rolling                      | 528        |
| Purified Water                           | 519        | Oxidizing                    | 528        |
| Deionized Water                          | 519        | Firing                       | 528        |
| Distilled Water                          | 519        | <b>Types of Tea</b>          | <b>528</b> |
| Reverse Osmosis Water                    | 519        | Black Tea                    | 528        |
| <b>Soft Drinks Marketed as “Water”</b>   | <b>519</b> | Green Tea                    | 528        |
| <b>Carbonated Soft Drinks</b>            | <b>520</b> | Oolong Tea                   | 528        |
| Early Soft Drinks                        | 520        | White Teas                   | 529        |
| Soft Drink Processing                    | 520        | Flavored Teas                | 529        |
| Soft Drink Health Concerns               | 520        | Herbal Teas                  | 529        |
| Diet Soft Drinks                         | 521        | Specialty Teas               | 529        |
| Food Additives in Soft Drinks            | 521        | <b>Grades of Tea</b>         | <b>529</b> |
| <b>Functional Beverages</b>              | <b>521</b> | <b>Composition of Tea</b>    | <b>529</b> |
| Nutraceutical Beverages                  | 521        | Health Benefits of Tea       | 529        |
| Nutraceutical Trends                     | 522        | <b>Preparation of Tea</b>    | <b>529</b> |
| Sports Beverages                         | 522        | Brewing Tea                  | 530        |
| Smart Beverages                          | 522        | Iced Tea                     | 530        |
| Energy Beverages and Shots               | 523        | Instant Tea                  | 530        |
|  |            | Microwaving                  | 530        |
| <b>Coffee</b>                            | <b>523</b> | <b>Storage of Tea</b>        | <b>530</b> |
| Coffee Processing                        | 524        | <b>Dairy Beverages</b>       | <b>530</b> |
| Removing the Hull                        | 524        | Cocoa Beverages              | 530        |



## **Alcoholic Beverages 530**

### **Beer 531**

- Beer Production 531
- Classifications of Beer 532
- Specialty Beers 532
- Serving Beer 532
- Storing Beer 532

### **Wine 532**

- Wine Production 533
- Evaluating Wines 533
- Selecting a Wine 534
- Food Additives in Wines 537

### **Spirits 537**

- Proof 537
- Common Spirits 537

## **PART IV FOOD INDUSTRY**

### **Chapter 28 Food Preservation 540**

#### **Food Spoilage 540**

- Biological Changes 540
- Chemical Changes 541
- Physical Changes 541

#### **Food Preservation Methods 542**

- Drying 542
  - Sun-Drying 542
  - Commercial Drying 542
- Curing 543
- Smoking Cured Meats 543
- Fermentation 544
- Pickling 544
  - Weak Organic Acids 544
- Edible Coatings 545
  - Composition of Edible Coatings 545
  - Commonly Coated Foods 545
  - Micro-encapsulation 545
- Canning 545
  - Preparing Food for Canning 545
  - Two Methods of Canning 546

#### **Cold Preservation 546**

- Refrigeration 546
  - Refrigerating Food 546
  - Refrigeration Temperatures and Times 546
- Freezing 546

- Foods Suitable for Freezing 546
- Freezer Storage Times 546
- Four Problems with Frozen Food 547

#### **Heat Preservation 544**

- Boiling 548
- Pasteurization 548
  - High-Temperature Pasteurization 548
  - Sous-vide 548
- Ohmic Heating 548

#### **Other Preservation Methods 548**

- Irradiation (Cold Pasteurization) 548
  - The Irradiation Process 549
  - Effects of Irradiation on Foods 549
  - Irradiation Pros and Cons 550
- Radio Frequency 551
- Pulsed Light 551
- High-Pressure Processing 551
- Ozonation 551
- Aseptic Packaging 552

#### **Modified-Atmosphere Packaging (MAP) 552**

#### **Controlled-Atmosphere Packaging (CAP) 552**

#### **Vacuum Packaging 552**

#### **Modified-Atmosphere Packaging (MAP) 552**

#### **Controlled-Atmosphere Packaging (CAP) 552**

#### **Vacuum Packaging 552**

#### **Modified-Atmosphere Packaging (MAP) 552**

#### **Controlled-Atmosphere Packaging (CAP) 552**

#### **Vacuum Packaging 552**

#### **Nutrient Retention 552**

### **Chapter 29 Government Food Regulations 555**

#### **Federal Food Laws 555**

- Pure Food and Drug Act (1906) 556
- Federal Food, Drug, and Cosmetic Act (1938) 556
- Numerous Government Agencies 556

#### **Food And Drug Administration 557**

- Research/Education 557
- The Code of Federal Regulations 557
- FDA Inspections 557
  - FDA Enforcement of Its Laws 557
  - Allowable Contaminants 558
- FDA Standards 558
  - Standards of Identity 558
  - Standards of Minimum Quality 558
  - Standards of Fill 559

#### **Food Labeling 559**

- Nutrition Facts Label 559
- Food Labeling Exemptions 560

|  |            |
|--|------------|
| Food Allergen Labeling                             | 560        |
| Genetically Modified Organisms (GMOs)              | 561        |
| FDA-Allowed Claims on Labels                       | 561        |
| Dietary Supplements                                | 562        |
| <b>Food Additives</b>                              | <b>563</b> |
| Safety of Food Additives                           | 563        |
| Ingredients Not Defined as Additives               | 563        |
| The Delaney Clause                                 | 563        |
| <b>The Bioterrorism Preparedness Act</b>           | <b>563</b> |
| <b>U.S. Department of Agriculture</b>              | <b>564</b> |
| USDA Inspections                                   | 564        |
| USDA Grading                                       | 565        |
| Quantity Grades or Yields                          | 565        |
| Quality Grades                                     | 565        |
| <b>Product Labeling</b>                            | <b>565</b> |
| Irradiated Foods                                   | 565        |
| Organic Foods                                      | 565        |
| Country of Origin Labeling (COOL)                  | 565        |
| <b>Environmental Protection Agency</b>             | <b>566</b> |
| <b>Centers for Disease Control and Prevention</b>  | <b>566</b> |
| <b>Other Regulatory Agencies</b>                   | <b>567</b> |
| U.S. Department of Commerce                        | 567        |
| Federal Trade Commission                           | 567        |
| Department of the Treasury                         | 567        |
| State Agencies                                     | 567        |
| <b>International Agencies</b>                      | <b>567</b> |
| The Food and Agriculture Organization              | 567        |
| The World Health Organization                      | 567        |
| European Regulation                                | 567        |
| <b>Chapter 30 Careers in Food and Nutrition</b>    | <b>570</b> |
| <b>Three Major Food and Nutrition Areas</b>        | <b>570</b> |
| <b>Nutrition Science and Dietetics</b>             | <b>571</b> |
| Nutrition Science                                  | 572        |
| Nutritionist                                       | 572        |
| Dietetics  | 572        |
| Registered Dietitian Nutritionist (RDN)            | 572        |
| <b>Types of Registered Dietitian Nutritionists</b> | <b>575</b> |
| Dietetic Technician, Registered (DTR)              | 576        |
| Dietary Clerk or Dietary Aide                      | 577        |
| <b>Food Science</b>                                | <b>577</b> |
| <b>Food Scientist</b>                              | <b>577</b> |
| Academic Requirements                              | 577        |
| Types of Food Scientists                           | 578        |
| <b>Food Science Technician</b>                     | <b>579</b> |
| <b>Food Service</b>                                | <b>579</b> |
| Academic Preparation for Culinary Arts             | 579        |
| <b>Types of Food-Service Positions</b>             | <b>579</b> |
| Chef   | 580        |
| Food-Service Manager                               | 580        |
| Sales and Marketing                                | 580        |
| Dietary Manager                                    | 580        |
| <b>Food-Service Certifications</b>                 | <b>580</b> |
| <b>Graduate School</b>                             | <b>580</b> |
| Prerequisites                                      | 580        |
| Academic Requirements                              | 581        |
| Examination Requirements                           | 581        |
| Professional Schools                               | 582        |
| <b>Graduate-Degree Jobs</b>                        | <b>582</b> |
| Researcher   | 582        |
| Professor  | 582        |
| Pharmaceutical and Nutraceutical Industries        | 583        |
| <b>APPENDIXES</b>                                  |            |
| A Food Preparation Equipment                       | A-1        |
| B Food Yields                                      | B-1        |
| C Substitution of Ingredients                      | C-1        |
| D Flavorings and Seasonings                        | D-1        |
| E Common Food Additives                            | E-1        |
| F Answers to Multiple-Choice Questions             | F-1        |
| <b>GLOSSARY</b>                                    | <b>G-1</b> |
| <b>INDEX</b>                                       | <b>I-1</b> |

# Preface

**Comprehensive** is the word that describes *Understanding Food: Principles and Preparation*, the best-selling textbook in its field. It brings together the most current information in food science, nutrition, and food service. Founded on research from more than thirty-five journals covering these disciplines, the text incorporates the very latest information on food—its science and its application. *Understanding Food: Principles and Preparation*, 6th edition, provides students with a broad foundation to launch a career in any of these food-related fields.

## ORGANIZATION OF CONTENT

*Understanding Food: Principles and Preparation* is organized according to the various food disciplines. Part I represents information related to food science and nutrition, such as food selection, sensory and physical evaluation, and food chemistry. Part II covers aspects of food service from food safety to food preparation basics to meal management. Part III covers all of the standard food items arranged into proteins (meat, poultry, fish, dairy, and eggs); phytochemicals (vegetables, fruits, soups, salads, and gelatins); complex carbohydrates (cereals, flour, and breads); refined carbohydrates and fat (sweeteners, fats and oils, cakes and cookies, pies and pastries, candy, and frozen desserts); and water (beverages) groupings. Part IV relates to the food industry in terms of food preservation, government food regulations, and food careers. The last chapter, on food careers, is an invaluable advisement session introducing students to the many careers in food and nutrition. In addition, the Career Corner feature found in many chapters spotlights individuals working in various areas of the nutrition and

food industry, so students really get a hands-on understanding of various career opportunities. Extensive appendixes provide additional key information, including approximate food measurements, weights and measures, storage temperatures, ingredient substitutions, flavorings and seasonings, and more.

## FEATURES

The unique features of this text allow flexibility in teaching and create a dynamic learning environment for students.

- **Career Corner** features provide interviews with people working in the food and nutrition arena to help students on their career path.
- **How & Why** inserts answer the questions most frequently asked by students, sparking natural curiosity and exercising the mind's ability to answer.
- **Chemist's Corner** features provide more advanced information on food chemistry for students and instructors who want to explore this topic further, allowing flexibility in the level of food chemistry presented within the individual course.
- **Calorie Control** teaches students how to identify food sources of kcalories, how many daily kcalories are recommended, and how to practice portion control.
- **Nutrient Content** boxes provide an overview of the nutritional composition of the foods.
- **Pictorial Summaries** are a proven favorite with readers. These pictorial chapter summaries use a combination of art and narrative text to encapsulate the key concepts in each chapter for student review.
- **Key terms**, boldfaced in the text, are defined on the same page to allow for quick review of the

essential vocabulary in each chapter. A glossary at the end of the book assembles all of the key terms in one place.

- **Functions of ingredients** are highlighted in the introduction to each chapter to aid students in successful food product development and food preparation. They introduce a focus of the food industry that is often missing in other books.
- **Food additive information** has been incorporated throughout the book.
- **Problems and causes tables** summarize the problems that may occur when preparing specific food products and describe the possible causes, providing students with a handy reference tool for deciphering “what went wrong.”
- **Chapter review questions** help students prepare for both their class exams and the Academy of Nutrition and Dietetics registration examination.

The dynamic world of food changes rapidly as new research constantly adds to its ever-expanding knowledge base. *Understanding Food: Principles and Preparation*, 6th edition, is designed to meet the needs of this evolving and expanding discipline and to provide students with a strong foundation in any food-related discipline that they select.

## NEW TO THIS EDITION

Each chapter of *Understanding Food* has been revised to reflect updates in research, government guidelines, consumer preferences, and food-service practices since the publication of the prior edition. Specific additions and other enhancements for the sixth edition follow:

- **COLOR.** This is the first time *Understanding Food: Principles and Preparation* is published in color as requested by many students.

- **MINDTAP.** Another first-time feature, MindTap, is included for online interactive textbook learning.
- **Chapter 1 Food Selection.** Added the NEW information from the 2015-2020 *Dietary Guidelines for Americans*, including MyPlate, updated statistics on diversity in the U.S. population, added new definitions for oleo-gustus, whole foods, processed foods, natural foods, discussed calorie requirements for restaurants, GMO crops, and food phytochemicals.
- **Chapter 2 Food Evaluation.** Added new food analyzer photograph.
- **Chapter 3. Chemistry of Food Composition.** Added standardized numbering system for food additives.
- **Chapter 4 Food Safety.** Added how HACCP was replaced by HARPC, the WHO (FERG) – Foodborne disease burden epidemiological reference group, how Norovirus is #1 with Salmonella close behind, defined Integrated Pest Management (IPM) Program, added gluten as a possible problem.
- **Chapter 5 Food Preparation Basics.** Added menu calorie requirements, mixing method table, photos of culinary herbs, induction cook top option, additional cutting styles (Batonnet, chiffonade, chop, pariseinnes), meniscus information, new rubs and pastes, mondoline figure, melon baller figure, and metric tables.
- **Chapter 6 Meal Management.** Inserted NEW 2016 USDA Adult Care Meal Pattern, updated terminology for registered dietitian nutritionist, and nutrition dietetic nutritionist, registered, modified nutrient box [removed decreasing dietary cholesterol, added decreasing saturated fat (10% kcal), decreasing added sugars (10% kcal)], removed the Exchange List, and added Use By, Best By and Sell By dates.
- **Chapter 7 Meat.** Color inserts were removed and inserted into this chapter for easier reference.
- **Chapter 8 Poultry.** The poultry classification table was upgraded with pics and new information, and salmonella amounts were modified ( $\frac{3}{4}$  and not  $\frac{1}{4}$ ).
- **Chapter 9 Fish & Shellfish.** NEW FDA mercury fish eating guidelines were added along with sushi definitions and photos.
- **Chapter 10 Milk.** New definitions were added for kefir, yogurt consistency, coconut milk vs water was clarified, camel milk was removed, Table 10-5 was corrected from 71.5 to 72 C, and a figure was added on probiotic food.
- **Chapter 12 Eggs.** Updates included egg consumption changing to 90 to 80 billion eggs, FDA safe egg handling tips, the number of whole eggs/whites/yolks per cup, along with new color figures to clarify information.
- **Chapter 11 Cheese.** Added two official government sources of cheese classification, a beautiful graphic of commercial cheese production, additional methods of inhibiting mold formation, yeast as a contributor to ripening, and quark cheese, common in Europe, to soft cheeses. Appendix E was moved to Table 11-1 showing origins of cheeses. Camel was removed as a source of cheese in Iran.
- **Chapter 13 Vegetables & Legumes.** Removed vitamin D as antioxidant, updated the Exchange List, NCI was updated to ‘no’ recommendations, improved descriptions of Fermented Soy Foods, and inserted the Color Inserts of vegetables into to this chapter.
- **Chapter 14 Fruits.** Two color inserts moved to this chapter (apples and exotic fruits), more fruits were added to Table 14-10 Climacteric and Non-climacteric fruits, and different types of olive processing were added.
- **Chapter 15 Soups, Salads, & Gelatins.** Two color inserts were moved to this chapter, koji definition was clarified, and additional herbs were depicted in color figures.
- **Chapter 16 Cereals Grains & Pasta.** Expanded Figure 16-1 to include colorful drawings of cereals on the stalk, Figure 16-7 illustrated different kernel types, inserted researching showing oats decrease blood cholesterol and glucose, updated cereal production figure, added chia seeds (popular new food), clarified the addition of oil to cooking pasta and improved the definition of “noodles” vs “Asian noodles.”
- **Chapter 17 Flours & Flour Mixtures.** Added Emmer (farro) grain to types of flour, psuedo-grains were better defined, added folic acid to masa flour recently approved by FDA, gluten-free definition by FDA reached final approval, clarified difference between semolina and durum flour, percentages of protein in text matched Table 17-1, and added Registered Trademark to kamut.
- **Chapter 18 Starches.** Clearer photographs on making a reduction were added.
- **Chapter 19 Quick Breads.** Added NEW table explaining different types of flatbreads.
- **Chapter 21 Sweeteners.** Updated NEWLY FDA approved Advantame sweetener, and improved the sugar alcohol table.
- **Chapter 22 Fats & Oils.** Improved chemistry by adding NEW chemistry figures describing fatty acid saturation and length, acrolein, hydrogenation, oxidation and antioxidant examples.
- **Chapter 23 Cakes & Cookies.** Inserted numerous photos of cakes and cookies.
- **Chapter 24 Pastries & Pies.** Inserted NEW photos of pies and pastries.
- **Chapter 25 Candy.** Improved definition of unsweetened, bittersweet, semi-sweet chocolates
- **Chapter 29 Government Food Regulations.** Included NEW FDA 2016 food label, NEW health claims, NEW topic of “Food Fraud,” and updated pesticide information.
- **Chapter 30 Careers in Food & Nutrition.** Updated terminology of RD to RDN, and DT to NDTR. Inserted salary updates.

## ANCILLARY MATERIALS

Assorted student and instructor support materials, thoroughly updated for the sixth edition, are available as follows:

- The print **Lab Manual**, revised by Janelle M. Walter (Baylor University), presents food experiments and recipes to demonstrate the principles discussed in the text. Pretest questions and materials/time needed information for instructors enhance the lab units, which parallel the organization and content of the text.
- **Cengage Learning Testing powered by Cognero**. A flexible, online system allows you to author, edit, and manage test bank content from multiple Cengage Learning solutions. Create multiple test versions in an instant. Deliver tests from your LMS, your classroom, or wherever you want. Test questions for this edition were written by Joan Aronson (New York University).
- An **Instructor's Manual** written by Joan Aronson and Cheryl Houston (Fontbonne University), available electronically, features engaging classroom activities, objectives, recommendations, and lecture outlines.
- **Instructor Companion Website**. Everything you need for your course in one place! This collection of book-specific lecture and class tools is available online at

[www.cengage.com/login](http://www.cengage.com/login). Access and download PowerPoint presentations, images, instructor's manual, videos, and more.

## ACKNOWLEDGMENTS

Many individuals assisted me in the development of this textbook. I want to thank Krista Mastroianni, the lead editor who masterfully brought this book to the completion of yet another edition, infused the book with new life by adding “color,” and inserted the online MindTap option for the very first time. Lauren Oliveira, Associate Content Development Manager for Life and Earth Sciences, got the book started on the right track.

I extend my thanks to the outstanding members of the Cengage nutrition editorial team: Oden Connolly, Associate Content Developer, for helping me revise and greatly enhance the artistic appeal of the sixth edition with incredible finesse and an incredible eye for artistic layout, design, and absolutely perfect photos. Your speedy attention to detail and quick communications propelled this book forward to the finish line. Marketing is everything, so thank you Tom Ziolkowski, Marketing Manager, for making this book sell successfully on numerous campuses where it counts. Elesha Feldman, once again weaved her invaluable editorial wizardry in revamping the text for the 6<sup>th</sup> edition.

A special thanks goes to the person who kindled my writing career, Nackey

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Finally, I wish to express my appreciation to the students. Were it not for them, I would not have taken pen to paper. I am grateful to be a part of your academic journey.

**Amy Christine Brown, PhD, RDN**  
**University of Hawaii at Manoa**  
**[amybrown@hawaii.edu](mailto:amybrown@hawaii.edu)**

# About the Author



Amy Brown

**Amy Christine Brown** received her PhD from Virginia Polytechnic Institute and State University in

Human Nutrition and Foods. She has been a college professor and a registered dietitian with the Academy of Nutrition and Dietetics since 1986. Dr. Brown currently teaches at the University of Hawaii's John A. Burns School of Medicine in the Department of Complementary and Integrative Medicine. Her research interests are in the area of medical nutrition therapy and bioactive plant substances beneficial to health. Some of the studies she has conducted include "Diet and Crohn's disease," "Potentially harmful herbal supplements," "Kava beverage consumption and the effect on liver function tests," and "The effectiveness of kukui nut oil in treating psoriasis." Selected research journal publications include "Position of the American Dietetic Association: Functional foods" (*Journal of the American Dietetic Association*); "The Hawaii Diet: Ad-

libitum high carbohydrate, low fat multi-cultural diet for the reduction of chronic disease risk factors" (*Hawaii Medical Journal*); "Lupus erythematosus and nutrition: A review" (*Journal of Renal Nutrition*); "Dietary survey of Hopi elementary school students" (*Journal of the American Dietetic Association*); "Serum cholesterol levels of nondiabetic and streptozotocin-diabetic rats" (*Artery*); "Infant feeding practices of migrant farm laborers in northern Colorado" (*Journal of the American Dietetic Association*); "Body mass index and perceived weight status in young adults" (*Journal of Community Health*); "Dietary intake and body composition of Mike Pigg—1988 Triathlete of the Year" (*Clinical Sports Medicine*); and numerous newspaper nutrition columns.

**Feedback welcome, contact:**  
**amybrown@hawaii.edu**

## *To Betsy Brown*

*The person who I love dearly, is one of the nicest people I know, sacrificed unflinchingly for me, and worked harder her whole life, as most Moms do, than I ever will. I deeply respect and love you for eternity. May the shining light that you created, brighten many candles to bring more light and love (Aloha) into the world.*

*Always and Forever,  
Amy Christine Brown*





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# Food Selection

|  |           |
|--|-----------|
| <b>Sensory Criteria</b> . . . . .                  | <b>1</b>  |
| <b>Nutritional Criteria</b> . . . . .              | <b>6</b>  |
| <b>Cultural Criteria</b> . . . . .                 | <b>11</b> |
| <b>Religious Criteria</b> . . . . .                | <b>12</b> |
| <b>Psychological and Sociological Criteria</b> . . | <b>14</b> |
| <b>Budgetary Criteria</b> . . . . .                | <b>17</b> |

**N**ot too long ago, **whole foods**, such as meats, milk, grains, nuts, vegetables, and fruits, were the only foods available for consumption. Today, food companies offer thousands of prepared and packaged foods, which are primarily mixtures of these basic ingredients, but often include natural and/or artificial additives. This wide assortment of **processed foods** makes planning a nutritious diet more difficult, rather than easier. Food companies compete fiercely to develop ever newer and more

attractive products. The food scientists they employ focus on why people eat, what they eat, and which food characteristics entice consumers to choose one brand over another.

People choose foods and beverages for at least five basic reasons: how foods look and taste; health, cultural, and religious values; environment; psychological and social needs; and budgetary concerns (16). This chapter addresses the factors influencing consumer food selection.

## SENSORY CRITERIA

People choose foods primarily by how they look, smell, taste, feel, and even sound (Figure 1-1). Sensory criteria are discussed first because how a food or beverage affects the senses is more important to most consumers than food selection criteria. The sensory criteria of sight, odor, and taste are now briefly summarized.

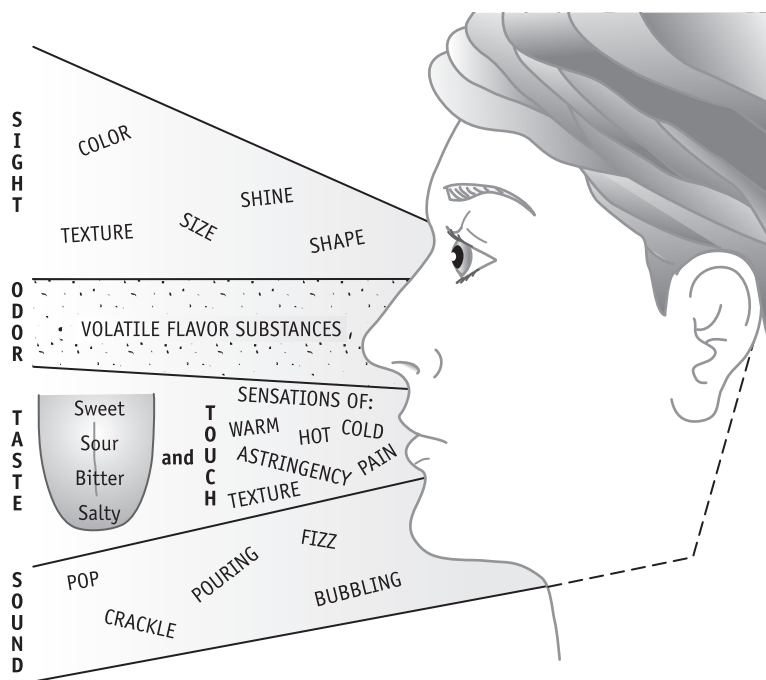
## Sight

The eyes see the first impression of foods: shapes, colors, consistency, serving size, and presence of any outward defects. Black bananas, barely yellow lemonade, meat cooked red raw, a cockroach eating cheese left out on the counter, and scorched macaroni send visual signals that may alter a person's choices. Color can be deceiving; if the colors of two identical fruit-flavored beverages are different, people often perceive them

**Whole Foods** Foods as you find them in their natural state, minimally processed, and free from additives or artificial ingredients.

**Processed Foods** Any deliberate change to a food before it is available to eat, such as salting, fermenting, drying, canning, freezing, packaging, or other types of processing.



**FIGURE 1-1** Sensory impressions of food provided by the five senses.

as tasting different even though they are exactly the same (80). People may judge milk's fat content by its color. For instance, if the color of reduced-fat (2%) milk is improved, it is often judged to be higher in fat content, smoother in texture, and better in flavor than the reduced-fat milk with its original color (5).

Chefs know that the color of foods on a plate is either appealing or detracting. Imagine being served a plate of baked flounder, mashed potatoes, boiled cabbage, and vanilla ice cream, and then compare it to one that contains a nicely browned chicken breast, orange sweet potatoes, green peas, and blueberry cobbler. Based on eye appeal alone, most people would prefer the latter.

## Odor

Chocolate chip cookies baking in the oven, coffee brewing, and spoiled meat makes smell almost as important as

appearance when evaluating foods and beverages for quality and desirability. Although the sense of smell is not as acute in human beings as it is in many other mammals, most people can differentiate between many thousands of odors. Recent research suggests that people's ability to distinguish smells is much greater than once thought. Researchers found the number of olfactory receptors to far exceed the 10,000 originally thought to be present with the number being as high as 1 trillion (4).

### Classification of Odors

Naming each of these thousands of odors separately would tax even the most fertile imagination, so researchers categorized them into major groups. One classification system recognizes six groups of odors: spicy, flowery, fruity, resinous (eucalyptus), burnt, and foul. The other widely used grouping scheme consists of four categories: fragrant (sweet), acid (sour), burnt, and caprylic (goaty) (4). A newer proposed classification divides odors into categories based on whether they are perceived as edible (e.g., fruit, candy, bakery, or spice) or inedible (e.g., clean, flower, and cosmetic) and overlaps with previous classification systems (94).

### Detecting Odors

Regardless of which classification is used, most odors are detected at very low concentrations. Vanillin can be smelled at  $2 \times 10^{-10}$  (0.0000000002) mg per liter of air (11). However, if an odor is repeatedly detected, the ability to distinguish between various odors diminishes over the time; and this perception of a continuously present smell gradually decreasing over time is called *adaptation*. People living near a noxious-smelling paint factory will, over time, come not to notice it, whereas visitors to the area may be taken aback by the odor.

How do we smell odors? They are detected when **volatile molecules** travel through the air, and some of them reach the yellowish-colored **olfactory epithelium**, an area the size of a quarter located inside the upper part of the nasal cavity. This region is supplied with olfactory cells that number from 10 million to 20 million in a human and about 100 million in a rabbit (11), reflecting the difference in importance

### ? How & Why?

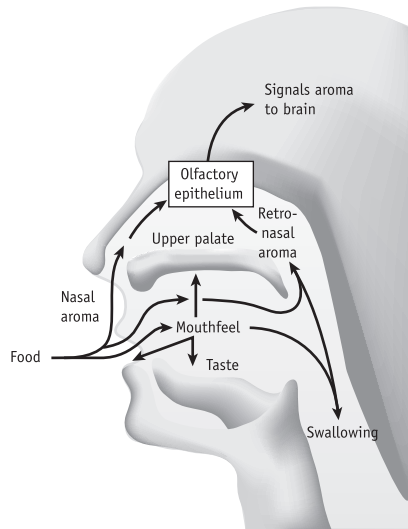
*Imagine the scent of chocolate chip cookies wafting through the house as they bake. How does this smell get carried to people? Why is the odor of something baking more intense than the odor of cold items like ice cream or frozen peaches?*

Heat converts many substances into their volatile form. Because only volatile molecules in the form of gas carry odor, it is easier to smell hot foods than cold ones. Hot coffee is much easier to detect than cold coffee. Relatively large molecules such as proteins, starches, fats, and sugars are too heavy to be airborne, so their odors are not easily noticed. Lighter molecules capable of becoming volatile are physically detected by the olfactory epithelium by one of two pathways: (1) directly through the nose, and/or (2) during eating when they enter the mouth and flow retronasally, or toward the back of the throat and up into the nasal cavity (Figure 1-2) (65).

**Volatile molecules** Molecules capable of evaporating like a gas into the air.

**Olfactory** Relating to the sense of smell.

**FIGURE 1-2** Detecting aroma, mouthfeel, and taste.



of the sense of smell between people and rabbits. The exact function of these specialized cells in the sense of smell is not well understood.

Interestingly, molecules can sometimes reach the olfactory epithelium by first going through the mouth and then back up to the nose. Who has not experienced the feeling of bubbles tingling in the nose brought on by drinking a carbonated beverage while simultaneously being made to laugh unexpectedly?

## Taste

Taste is usually the most influential factor in people's selection of foods (52). Taste buds—so named because the arrangement of their cells is similar to the shape of a flower bud—are located primarily on the tongue but are also found on the mouth palates and in the pharynx. These taste detectors are not found on the flat, central surface of the tongue, but rather on the tongue's underside, sides, and tip.

### Mechanism of Taste

What is actually being tasted? Many tasted substances are a combination of nonvolatile and volatile compounds. In order for a substance to be tasted, it must be dissolved in liquid or saliva, which is 99.5% water. In the middle of each taste bud is a pore, similar to a little pool, where saliva collects.

When food comes into the mouth, bits of it are dissolved in the saliva pools and they come into contact with the cilia, small hair-like projections from the gustatory cells. The **gustatory** cells relay a message to the brain via one of the cranial nerves (facial, vagus, and glossopharyngeal). The brain, in turn, translates the nervous electrical impulses into a sensation that people recognize as “taste.” As people age, the original 9,000 to 10,000 taste buds begin to diminish in number, so people over age 45 often find themselves using more salt, spices, and sugar in their food. Genetics also plays an important role in taste; for example, some people can detect monosodium glutamate (MSG) in foods because it contains glutamate. Another important factor influencing the ability of a person to taste is the degree to which a compound can dissolve (56). The more moisture or liquid is present, the more the molecules triggering flavor can dissolve and spread over the tongue to contact the taste buds (29).

### The Six Taste Stimuli

The common concept of a “tongue map,” in which different areas on the tongue are associated with the basic types of tastes—sweet, sour, bitter, and salty—has been largely discredited (12). Nonetheless, the four basic tastes, along with a fifth known as savory (*umami*, a Japanese word meaning “delicious”), and now a sixth taste for fat (**oleogustus**, a Latin word meaning “taste for fat”), have been proposed (52). All are perceived in response to certain chemical stimuli. The time it takes to detect taste stimuli varies from a split second for salt to a full second for bitter substances (11). Bitter tastes, therefore, have a tendency to linger. The chemical basis of these five categories of taste is as follows:

- **Sweet.** The sweetness of sugar comes from the chemical configuration of its molecule. A long list of substances yield the sweet taste, including sugars, glycols, alcohols, and aldehydes. Little is known, however, about the sweet taste receptor and how “sweetness” actually occurs (29).
- **Sour.** Food acids deliver the sour taste found in food. It is related to the concentration of hydrogen ions ( $H^+$ ), which are found in the natural



Stockbyte/Jupiter Images

acids of fruits, vinegar, and certain vegetables. The perceived unpleasantness of too much sour food may protect against disrupting the body's acid-base balance (12).

- **Bitter.** Bitterness is imparted by compounds such as caffeine (tea, coffee), theobromine (chocolate), and phenolic compounds (grapefruit). Many other substances yield bitter tastes, including the alkaloids often found in poisonous plants (6). Thus, the ability to taste bitterness can warn us against ingesting some toxins.
- **Salty.** Salty taste comes from ionized salts—for example, from the sodium ions ( $Na^+$ ) in sodium chloride ( $NaCl$ ) or other salts found naturally in some foods.
- **Umami (savory).** This taste was first identified in 1908 by researchers at Tokyo Imperial University. *Umami* is attributed to glutamate, an amino acid that imparts the taste of beef broth but without the salt (46).
- **Oleogustus.** This wordy mouthful is Latin for “taste for fat.” It's new. Purdue University researchers recently identified and added oleogustus as the sixth taste. They demonstrated that medium- and long-chain esterified fatty acids produce a unique taste sensation separate from the basic tastes already identified above (52).

**Gustatory** Relating to the sense of taste.

**Oleogustus** A proposed sixth taste for the unique flavor of fat, from the Latin for “taste for fat.”

## Taste Interactions

Each item used in food preparation contains several compounds, and bringing these items together creates new tastes when all their compounds interact.

## Factors Affecting Taste

Not everyone perceives the taste of apple pie the same way. There is considerable genetic variation among individuals in sensitivity to basic tastes (52). Tasting abilities may also vary within the individual, depending on a number of outside influences. One such factor affecting taste is the temperature of a food or beverage. Taste buds operate best at temperatures of around 86°F (30°C). As the temperature of foods or beverages goes below 68°F (20°C) or above 86°F (30°C), it becomes harder to distinguish their tastes accurately. For example, very hot coffee tastes less bitter, whereas slightly melted ice cream tastes sweeter. Other factors influencing taste include the color of the food; the time of day it is eaten; and the age, sex, and degree of hunger of the taster (30). Psychological factors, such as preconceived ideas based on appearance or on previous experiences with a similar food, also affect a person's perception of taste. For instance, cherry-flavored foods are expected to be red, but if they are colored yellow, they become difficult to identify as cherry. In addition, unpleasant experiences associated with a food may influence the perceived taste of that food in the future.

Variety in available food choices also affects taste. This can be seen when the “taste,” or appetite, for a food eaten day after day starts to diminish. Even favorite foods can eventually lose their appeal when consumed daily. Some weight-reducing fad diets that severely restrict choices are based on the idea that people will get tired of eating just one type of food and therefore eat less. A routine of grapefruit for breakfast, grapefruit for lunch, and grapefruit for dinner quickly becomes boring and unappetizing.

## Definition of Flavor

It's important to know that taste is not the same thing as **flavor**. Taste depends

**Flavor** The combined sense of taste, odor, and mouthfeel.

## ? How & Why?

*Why does a dash of salt make some foods sweeter?*

Taste sensitivity depends on a number of factors, including (1) the amount of time allowed to taste a substance, (2) the concentration of the substance generating the taste, and (3) the individual's ability to detect various tastes. The threshold concentration is the minimum concentration required to detect a substance. This is not easy to determine because people more sensitive to a particular taste than others can detect it at a lower concentration. Below the threshold concentration are subthreshold concentrations that are not detected but may influence the person's ability to perceive other tastes. For example, subthreshold salt levels increase perceived sweetness while decreasing perceived acidity, even though the actual amount of sugar or acid in the food is unchanged. Conversely, subthreshold sugar or acid concentrations make a food taste less or more salty, respectively. This principle can be applied to foods when too much salt is added to soups or stews. Even though the salt cannot be removed, adding a small amount of sugar will make the dish taste less salty (60). Trace additions of sugar also make acids taste less sour and coffee or tea less bitter. Small amounts of salt sprinkled on grapefruit or added to fruit pies tend to decrease tartness and enhance sweetness. Some compounds, such as monosodium glutamate (MSG), often used in Chinese cooking, actually improve the taste of meat and other foods by making them sweeter (34).

solely on the taste buds' connection to the brain via nerve cells to signal the sensations of sour, salt, sweet, bitter, umami (savory), and oleogustus (fat). Flavor is a broader concept that encompasses taste, odor, and mouthfeel. The perception of odor is triggered by volatile compounds reaching the nose and provides about 75 to 95% of the impression of flavor (79). Thus, a food without aroma has very little flavor. To get some idea of how the ability

## ? How & Why?

*How are food flavors preserved during storage?*

Flavors, regardless of the medium in which they are dissolved, do not stay at the same intensity day after day but diminish over time. Sensory chemists and flavor technologists know that one way to keep the food products sold by manufacturers from losing their appeal is to prevent the volatile compounds responsible for flavor from deteriorating, escaping, or reacting with other substances. In devising flavor preservation strategies, they look at processing, storage, and cooking methods, all of which affect the volatile flavor compounds. One of the major functions of protective packaging is to retain a food's flavor. Packaging guards flavor in several ways. It protects against vaporization of the volatile compounds and against physical damage that could expose food to the air and result in off odors. It keeps unpleasant odors from the outside from attaching to the food. It also prevents “flavor scalping”—the migration of flavor compounds from the packaging (sealers, solvents, etc.) to the food or vice versa (44).

to smell affects flavor perception, think of having a cold with a badly stuffed-up nose. Everything tastes different. The nasal congestion interferes with the function of the olfactory sense, impairing the ability to detect the aromas contributing to the perception of flavor. Some people apply this principle to their advantage by pinching their nostrils shut to lessen the bad flavor of a disagreeable medicine they must swallow.

Whether in a package or on a plate, a commercial food's flavor is the single most important factor determining marketplace success (52).

## Touch

The sense of touch, whether it operates inside the mouth or through the fingers, conveys to us a food's texture, consistency, astringency, and temperature. These terms are important to the

## CAREER CORNER

### Ben Cohen and Jerry Greenfield— Cofounders of Ben & Jerry's

It's hard to believe, but some people taste food for a living. "Taste testers" have such sensitive taste buds or olfactory detection that they are hired by food companies to taste new products being developed. Food companies need to be sure that the absolute best product is being produced for consumers. The first taste tester at Ben & Jerry's Ice Cream was the company's cofounder, Ben Cohen. He had such weak taste buds that he kept asking the flavor developers for more sugar, salt, chocolate cookies, or caramel. His challenged taste buds made Ben & Jerry's ice creams famous for their intense flavors.



Ben Cohen and Jerry Greenfield

Steve Liss/Time Life Pictures/  
Getty Images

with Jerry, whose application to medical school had been rejected twice. Their first store was "Ben & Jerry's Homemade Ice Cream Parlor" in a renovated gas station in Vermont. The rest is ice cream history ([www.benjerry.com](http://www.benjerry.com)).

Ben & Jerry's started small. Ben Cohen and Jerry Greenfield were high school friends, and Ben drove an ice cream truck selling ice cream pops to kids. He went to college, dropped out, and returned to his ice cream job. Ben also taught crafts in a residential school for emotionally disturbed children, where he began experimenting with making ice cream as a craft activity for the students. This led to him selling ice cream

food industry, which constantly evaluates its food products for these qualities using surveys or other measuring instruments.

Texture is critical for consumer acceptance and is based on a combination of perceptions, with the eyes giving the first clue. The second comes at the touch of fingers and eating utensils, and the third is mouthfeel, as detected

by the teeth and the tactile nerve cells in the mouth. Textural or structural qualities are especially obvious in foods such as apples, popcorn, liver, crackers, potato chips, tapioca pudding, cereals, and celery, to name just a few. Textures can be described as coarse (grainy, sandy, mealy), crisp, fine, dry, moist, greasy, smooth (creamy, velvety), lumpy, rough, sticky, solid, porous, bubbly, or flat. Tenderness, which is somewhat dependent on texture, is judged by how easily the food gives way to the pressure of the teeth.

**Consistency** is only slightly different from tenderness; it is expressed in terms of brittleness, chewiness, viscosity, thickness, thinness, and elasticity (rubbery, gummy).

**Astringency**, which causes puckering of the mouth, is possibly due to the drawing out of proteins naturally found in the mouth's saliva and mucous membranes (11). Foods such as cranberries, lemon juice, and vinegar have astringent qualities.

Another term used in the sensory perception of foods is **chemesthesis**. Chemesthesis defines how certain foods that are not physically hot or cold appear to give the impression of being "hot" (hot salsa) or "cooling" (cucumbers) when placed on the tongue (32). Although extremely hot temperatures can literally burn the taste buds (they later regenerate), the other kind of "heat" experienced with food results from eating "hot" peppers (Chemist's Corner 1-1). Capsaicin (cap-SAY-iss-in) is the chemical responsible for the

"heat" that many people enjoy in moderation, as well as the real pain experienced when an excess irritates nerves in the nose and mouth. In fact, this compound is so caustic when concentrated

### ? How & Why?

*Why do flavors differ in how quickly they are detected or how long they last?*

The amount of fat in a food or beverage determines how intense the flavor is over time. Flavor compounds dissolved in fat (fat-soluble compounds) take longer to be detected and last longer than flavor compounds dissolved in water (water-soluble compounds), which are quickly detected but also disappear much more quickly (17). This explains why a reduced-fat product is unlikely to duplicate the flavor of the original food: the original fat's flavor compounds are missing, causing an imbalance of the other flavors present. Reduced-fat cookies, for example, taste sweeter unless they are modified to compensate for this difference (44). It is even more difficult to replace certain fats that have their own distinctive flavor, such as butter, olive oil, and bacon fat.



### CHEMIST'S CORNER 1-1

#### Hot Peppers and Body Chemistry

The warming sensation experienced by some people eating hot peppers (or foods made with them) is due to the body's secreting catecholamines, a group of amines composed of epinephrine (adrenaline), norepinephrine (noradrenaline), and dopamine. These catecholamines activate the "fight-or-flight" response, which normally triggers an increased respiration rate, a faster heartbeat, slowed digestion, widened pupils, and enhanced energy metabolism (67).

**Consistency** A food's firmness or thickness.

**Astringency** A sensory phenomenon characterized by a dry, puckery feeling in the mouth.

**Chemesthesis** The ability to feel a food's chemical properties (e.g., cool mints or hot chili peppers).

that it is used by many law enforcement agencies in place of mace-like sprays.

## Hearing

The sounds associated with foods can play a role in evaluating their quality. How often have you seen someone tapping a melon to determine its ripeness? Sounds such as sizzling, crunching, popping, bubbling, swirling, pouring, squeaking, dripping, exploding (think of an egg yolk in a microwave), and crackling can communicate a great deal about a food while it is being prepared, poured, or chewed. Most of these sounds are affected by water content, and their characteristics thus give clues to a food's freshness and/or doneness.

## NUTRITIONAL CRITERIA

Over the past several decades, emerging scientific evidence about health and nutrition has resulted in changing food consumption patterns in the United States (64). Past surveys reveal that at least half of all consumers were reportedly making a major change in their diets, with nutrition being second only to taste in importance to shoppers (83). Currently, about 71% of Americans say they are trying to limit the intake of some type of fats, and 66% of Americans say they are trying to limit their consumption of saturated fats and/or trans fatty acids. More than half of Americans are trying to limit their consumption of sugars (40). Attempts to improve food habits are related to the increased awareness that a poor diet can be related to some of the leading causes of death—heart disease, cancer, and diabetes—as well as to other common health conditions such as osteoporosis, diverticulosis, and obesity (33).

**Calorie** The amount of energy required to raise 1 gram of water 1°C (measured between 14.5°C and 15.5°C at normal atmospheric pressure). A *kilocalorie* (kcalorie, kcal), the unit commonly used to measure food energy, is equal to 1,000 calories.

## Weight Management

Obesity has reached epidemic proportions in the United States (33). As a risk factor for heart disease, cancer, type 2 diabetes, and other health conditions, obesity is one of the biggest and costliest health problems in the nation. Health-care costs are higher for people who are obese as compared to people of normal weight; it is estimated that the direct medical cost of overweight and obesity is 5 to 10% of all health-care spending (81). In addition, billions are spent annually by millions of North Americans seeking “quick fix” weight-loss solutions, most of which achieve no permanent results. According to an International Food Information Council survey, most Americans (69%) are trying to reduce or maintain their weight (41). They consider this a strong factor influencing their decision to make dietary changes and remain physically active.

Generally, individuals must restrict their intake of food energy and increase their expenditure of energy (e.g., through bodily movement) in order to lose weight. Energy can be correlated to heat and is measured in units called **calories** (or joules or Btu; see Chemist's Corner 1-2). Food energy is measured in kilocalories (abbreviated kcalories or kcal). The “Measuring Heat Energy” section in Chapter 3 provides

further details. Because a calorie is a unit of measure, not a component of foods (or of the body), it is more accurate to speak of energy rather than calories, unless a specific amount is being discussed. The “Calorie Control” features found in many chapters of this book explain the basics of weight management and provide practical guidelines for making lower-kcalorie food choices to reduce energy intake.

## Dietary Guidelines for Americans

In an effort to reduce dietary risk factors for some of the major health conditions affecting Americans, the U.S. Department of Agriculture (USDA) and the U.S. Department of Health and Human Services (DHHS) have published the *Dietary Guidelines for Americans* every 5 years since 1980 (86). The 2015–2020 *Dietary Guidelines* for healthy adults published in January 2016 represents the federal government's evidence-based nutritional guidance to promote health, reduce the risk of chronic diseases, and reduce the prevalence of overweight and obesity through improved nutrition and physical activity. They also serve to guide federal food programs and nutrition education programs (84). They encourage people to follow the recommendations available at <http://health.gov/dietaryguidelines/2015/guidelines/executive-summary>. In general, a healthy diet emphasizes the following:

- Following a healthy eating pattern across the life span
- Focusing on a variety of nutrient-dense foods in an amount to meet nutrient needs within calorie limits
- Limiting calories from added sugars and saturated fats while reducing sodium intake
- Shifting to healthier food and beverage choices
- Supporting healthy eating patterns for all

Everyone has a role in helping to create and support healthy eating patterns in multiple settings nationwide.

## ChooseMyPlate

MyPlate is a pictorial illustration of the concepts of the 2010 *Dietary Guidelines*. It shows people what to put on



### CHEMIST'S CORNER 1-2

#### Other Units of Measurement for Energy

The metric equivalent of the calorie is the joule (J) or kilojoule (kJ). One joule is defined as the work or energy required to move 1 kilogram of mass 1 meter. One calorie is equivalent to 4.184 joules, whereas 1 kilocalorie equals 4.2 kilojoules. Another measure of heat is the British thermal unit (Btu), which is the amount of energy required to raise the temperature of 1 pound of water 1 degree Fahrenheit. The Btu is more commonly used to measure the heating capacity of fuels used in various industries (heating, power, steam, and air conditioning).



## CALORIE CONTROL

### Calorie Balance

One out of every three people in the United States was classified as “obese” in 2014 according to the Centers for Disease Control and Prevention (CDC) (9). A website link at the end of this chapter allows each person to calculate his or her body mass index (BMI). This number is a ratio based on a person’s weight to height that classifies him or her as underweight, normal weight, overweight, or obese.

The CDC is concerned about obesity because of the health consequences, high health-care costs, increased absenteeism, and work-related injuries (43). Although many other factors such as environment, genetics, disease, and drugs may contribute to obesity, this book focuses on the primary cause of obesity—too many kcalories (Figure 1-3).

The purpose of the “Calorie Control” sections in this book is to address the obesity epidemic by providing readers with kcalories found in foods and healthful ways to modify their diets. Specific topics to be included are (1) average daily caloric intakes by Americans (see below), (2) kcalorie sources (see Chapter 3, “Chemistry of Food Composition”), (3) the average number of kcalories found in foods (see individual chapters), (4) suggestions for practicing portion control (see Chapter 5, “Food Preparation Basics” and various individual chapters), and (5) healthful preparation methods (various chapters).

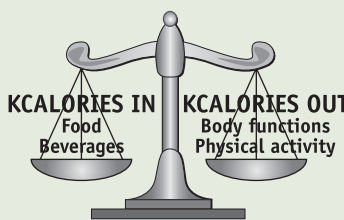
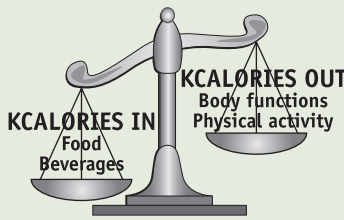
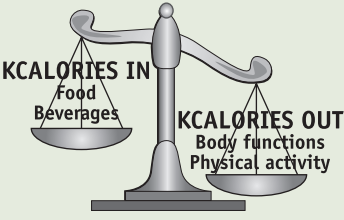
#### How Many Kilocalories Do People Consume Each Day?

The Dietary Reference Intakes (DRI) for kcalories (2,403 per day for women and 3,067 for men) exceed those reported by the National Health and Nutrition Examination Survey (2009–2010), which measures the actual kcaloric intakes (1,778 for women and 2,512 for men over 20 years of age) of a population in which one-fourth are obese (9). Although it’s best for people to determine their specific caloric and nutrient needs by seeing a registered dietitian (RD) or using the USDA’s SuperTracker ([www.choosemyplate.gov/SuperTracker/CreateProfile.aspx](http://www.choosemyplate.gov/SuperTracker/CreateProfile.aspx)), the intakes below serve as general guidelines for healthy adults who want to “reach” and “maintain” a healthy goal weight:

|       |  |
|-------|--|
| Women | Approximately 1,600 kcalories for each day       |
| Men   | Approximately 2,400–2,600 kcalories for each day |

This estimate includes exercising three times a week for at least 20 minutes each session. A person will need more kcalories if he or she exercises more than three times a week—approximately 300 to 600 kcalories for each hour of aerobic exercise. The exceptions are active (athletes) and larger people, who need more calories; sedate and shorter people, who need fewer calories; and older people, who need fewer kcalories (after 40, people need 100 fewer kcalories for each 10 years of age) (86).

**FIGURE 1-3** Caloric balance is like a scale. To remain in balance and maintain your body weight, the kcalories consumed (from foods) must be balanced by the kcalories used (in normal body functions, daily activities, and exercise).

| If you are:        | Your caloric balance is:   |
|--------------------|--|
| Maintaining Weight |  <ul style="list-style-type: none"> <li>• “IN BALANCE”</li> <li>• You are eating roughly the same number of kcalories that your body is using.</li> <li>• Your weight will remain stable.</li> </ul>  |
| Gaining Weight     |  <ul style="list-style-type: none"> <li>• “IN KCALORIC EXCESS”</li> <li>• You are eating more kcalories than your body is using.</li> <li>• You will store these extra kcalories as fat and you’ll gain weight.</li> </ul>                    |
| Losing Weight      |  <ul style="list-style-type: none"> <li>• “IN KCALORIE DEFICIT”</li> <li>• You are eating fewer kcalories than you are using.</li> <li>• Your body is pulling from its fat storage cells for energy, so your weight is decreasing.</li> </ul> |

(Continued)

**How Many Kilocalories for Each Meal?**

Because it's challenging to count total daily kcalories, the easier method is to break it down for each "meal." For example, a woman requiring 1,600 kcalories (kcal) a day could divide this into three 400-kcalorie meals plus one 400-kcalorie snack (or two 200-kcalorie snacks). The snacks are best eaten midmorning and midafternoon but can be taken in any combination of kcalories during any part of the day and even as part of a meal. A man requiring 2,400 kcalories a day could divide this into three 600-kcalorie meals plus one 600-kcalorie snack (or two 300-kcalorie snacks).

**Starving Is a Bad Idea**

About two-thirds of a person's kcalories are used to sustain life: heart beating, lungs breathing, body temperature at 97.6°F (36.4°C), and other bodily functions. Most of the remaining 30% of kcalories are burned by activity.

The bottom line is that based on gender, a person should not consume less than the following amount of daily kcalories:

|       |                                      |
|-------|--------------------------------------|
| Women | 1,200 kcalories (about 70% of 1,600) |
| Men   | 1,600 kcalories (about 70% of 2,400) |

**How to Gain or Lose Weight**

The recommended method of gaining or losing weight is to either increase or decrease caloric intake, respectively, by at least

500 kcalories a day. This should result in a weekly 1-pound weight gain or loss, respectively.

**How Many Kilocalories Equal a Pound?**

3,500 kcalories = 1 pound

To lose 1 pound = Consume 3,500 kcalories less and/or burn it off with exercise

To gain 1 pound = Consume 3,500 kcalories over what your body burns

**Combination of Diet and Exercise**

If a person can achieve a deficit of 500 kcalories per day through diet and/or exercise, he or she will lose approximately 1 pound a week.

**Successful Weight Loss Is Usually Slow**

Consistency is the goal. The slower you lose the weight, the more likely it will stay off.

1 pound a week for 1 month = 4 weeks = 4 pounds

1 pound a week for 1 year = 52 weeks = 52 pounds

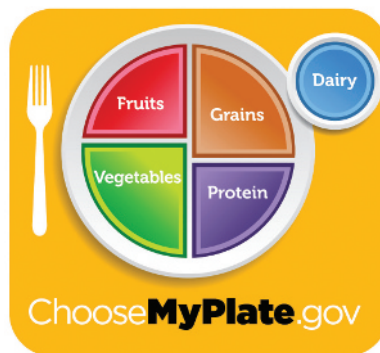
their plate by dividing it into four sections—vegetables, fruits, grains, and protein foods (Figure 1-4) (85). The [www.choosemyplate.gov](http://www.choosemyplate.gov) website provides interactive tools to assist people in creating a personalized **food group plan** based on the *Dietary Guidelines* and taking small steps toward making better daily food and lifestyle choices. One such step could be to shift from beverages with added sugars to no-sugar added drinks, especially because almost half of all sugar is consumed from sugar-sweetened soft drinks, fruit drinks, coffee, tea, energy drinks, and flavored water (75).

**SuperTracker**

The SuperTracker is an online diet and physical activity tracking tool available at [www.supertracker.usda.gov](http://www.supertracker.usda.gov). Here, consumers can look up individual foods to see or compare their nutritional

**Food group plan** A diet-planning tool that groups foods together based on nutrient and/or kcalorie content and then specifies the amount of each group a person should consume based on their recommended kcalorie intake.

**FIGURE 1-4** MyPlate: A pictorial demonstration of the 2010 *Dietary Guidelines*.



Source: U.S. Department of Agriculture.

values, find recommendations for what and how much to eat, and compare food choices to these recommendations and their personal nutrient needs (70). The USDA's Food Composition Databases, from where most nutrient analysis software is derived, lists the nutrient ingredients of many foods and can be found at <https://ndb.nal.usda.gov/ndb>.

**Previous Food Group Plans**

MyPlate is a successor to several previous food plans, including MyPyramid (released in 2005) and the Food

Guide Pyramid (1992), all developed to encourage Americans to improve their diets. One of the first food group plans was the basic four food groups of milk, meat, vegetable/fruit, and bread/cereal (28). Other countries have their own versions of dietary guidelines; Canada's version is available online (see websites at the end of chapter).

**Vegetarianism**

About 3 to 4% of the U.S. population does not consume meat, poultry, or seafood, and approximately 1% of adults are vegan (25), compared to approximately 15% of college students who define themselves as vegetarians. The Academy of Nutrition and Dietetics has suggested that properly planned vegetarian diets may reduce the risk of certain chronic, degenerative diseases and conditions, including heart disease, some cancers, diabetes mellitus, obesity, and high blood pressure (38). Other factors, however, may contribute to the decreased morbidity and mortality from these diseases among vegetarians. These include positive lifestyle differences such as lower rates of smoking and drinking. Nevertheless, the benefits of vegetarian diet probably come from lower intakes of fat, saturated fat, cholesterol, and animal

protein, balanced by higher levels of phytochemicals, fiber, complex carbohydrates, **antioxidants** such as vitamins C and E, carotenoids, and folate (a B vitamin) (53). The World Cancer Research Fund (WCRF) and American Institute for Cancer Research (AICR) cancer-prevention strategies state that one's risk of cancer can be reduced by maintaining a healthy weight throughout life, consuming a diet high in plant-based foods, limiting intakes of red meat, avoiding salty foods and processed meat, and consuming alcohol in modest amounts, if at all (42).

## Consumer Dietary Changes

As a result of these dietary guidelines and other influences, consumers have shifted their dietary concerns and intakes, and more people are reading the Nutrition Facts on food labels to understand what they are consuming (Chapter 29). Throughout the 1990s, consumers reported that their biggest

nutritional concern was fat (76). Today, Americans are ingesting less milk and more poultry, fish, fresh vegetables, and grains. As a result, fat consumption has dropped from 42% of kcalories in the mid-1960s to less than 33% today (10). Despite some positive dietary trends, progress remains to be made by Americans in order to meet the *Dietary Guidelines for Americans*, as shown in Figure 1-5.

### Kcalories on Menu

The latest assistance with diet comes from the FDA's requirement to list kcalories on menu items in restaurants with 20 or more locations (61).

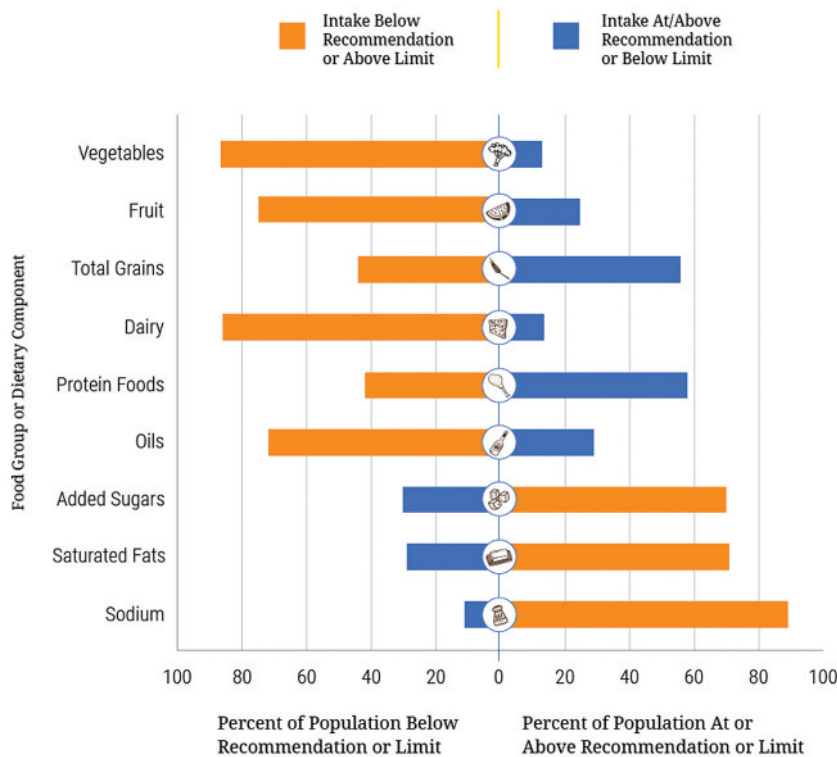
### Complementary and Integrative Medicine

Another influence on consumer dietary changes is complementary and integrative medicine (CIM), or complementary and alternative medicine (CAM), which is making permanent inroads in the U.S. medical landscape. Terms such as **nutraceuticals** and **functional foods**

(described more fully following this section) are becoming commonplace. In the United States, *nutraceuticals* is used to refer to dietary supplements (includes herbs), while the official definition in Canada is "a product isolated or purified from foods, and generally sold in medicinal forms not usually associated with food and demonstrated to have a physiological benefit or provide protection against chronic disease" (35). About 50% of Americans take a multivitamin supplement, while about 30% have used herb products (3). The use of herbal medicinal products and supplements has increased tremendously over the past three decades with not less than 80% of people worldwide relying on them for some part of primary health care (19).

Europe and Japan lead the way in complementary medicine. In Germany, the E Commission was created in 1978 to ensure product standardization and safe use of herbs and phytomedicines. Composed of a body of experts from the medical and pharmacology professions, the pharmaceutical industry, and laypersons, the E Commission studies the scientific literature for research data on herbs based on clinical trials, field studies, and case studies. It has created a collection of **monographs** representing the most accurate information available in the world on the safety and efficacy (power to produce effects or "does it work?") of herbal products. Germany

**FIGURE 1-5** What Americans eat versus what the 2010 *Dietary Guidelines* recommends they should eat.



\*SoFAS = solid fats and added sugars.

**Source:** U.S. Department of Agriculture and U.S. Department of Health and Human Services. *Dietary Guidelines for Americans*, 2010. 7th ed. U.S. Government Printing Office, Washington, DC: December 2010.

**Antioxidant** A compound that inhibits oxidation, which can cause deterioration and rancidity.

**Nutraceutical** A bioactive compound (nutrient or nonnutrient) that has health benefits.

**Functional food** A food or beverage that imparts physiological benefits that enhance overall health, prevents or treats a disease or condition, and/or improves physical/mental performance.

**Monograph** A summary sheet (fact sheet) describing a substance in terms of name (common and scientific), chemical constituents, functional uses (medical and common), dosage, side effects, drug interactions, and references.