

# Index

Note: The letters 'f' and 't' following the locators refer to figures and tables respectively

## A

Accelerated Shelf Life Testing (ASLT), 35, 35t

Acetic acid bacteria, 251, 254, 258, 263, 265t, 266, 268t, 269

Acidenzyme process, 311

Acidified specialty products

detection of microorganisms, 297

MEA/TGYA, 297

economic loss, 286

factors affecting spoilage, 287–289

headspace oxygen content, 289

pasteurization, 288

pH and type of acidulant, 287–288, 288t

preservatives and partition coefficient, 288–289

refrigeration, 289

water activity, 288

French dressing, 293, 294t

growth of aceto-tolerant spoilage microorganisms, 297t

ketchup, 295

mayonnaise, 287–289

mustard, 296

pourable salad dressings, requirements, 293–295

spoilage defects, 290

spoilage microorganisms, 286–287

spoonable salad dressings, 291–293, 292t

vinegar, 296–297, 297t

yeasts from low-pH products, 287t

Acidophiles, 8, 10

Acid's dissociation constant ( $pK_a$ ), 18

Aciduric flat sour sporeformers, 212

"Acidurics," tolerate low pH values, 8, 275

*Acinetobacter*, 9, 23t, 77, 79, 129, 155, 229, 247

Actinomycetes, 4, 247

5-A-Day Challenge, 136

Aerobic microorganisms, 7, 20, 22, 75, 80, 91, 94, 161, 231, 237, 286

Aerobic plate counts (APC), 163  
procedures, 34, 35

Aerobic psychrotrophic bacteria, 163

Aged, ripened cheeses, 51

*Alicyclobacillus*, 9, 10, 32, 33, 212, 262, 277t, 278, 279t

American Meat Institute, 76

Amyolytic enzymes, 12

Anastomosing fibers, 125, 126

Antagonisms, 13

Antimicrobial process, 238

Application of appropriate pasteurization, 270–271

APP technology, *see* Aseptic processing and packaging (APP) technology

*Art of Preserving All Kinds of Animal and Vegetable Substances for Several Years, The*, 185

Aseptic process, 24, 204, 206, 274

Aseptic processing and packaging (APP) technology, 274

ASLT, *see* Accelerated Shelf Life Testing (ASLT)

Atmospheric steam pasteurization, 25

Auto-sparging systems, 274

Autosterilization, 202, 205

*See also* Canned foods

Awareness of common CSD contamination vectors, 254

## B

*Bacillus*, 9, 10, 16t, 17t, 22, 23t, 26t, 45, 46, 95t, 99t, 129, 140t, 197, 202, 206, 207t, 209, 212, 213, 225t, 235, 240, 277, 295, 303, 305t, 307t, 310, 315t, 331

Bacon, 77–78

BacT/Alert<sup>®</sup>, 205

**Bacteria**

- Acinetobacter*, 9, 23*t*, 77, 79, 129, 155, 229, 247
- Alicyclobacillus*, 9, 10, 32, 212, 262, 277*t*, 278, 279*t*
- Bacillus*, 9, 10, 16*t*, 17*t*, 22, 23*t*, 26*t*, 45, 46, 95*t*, 99*t*, 129, 140*t*, 197, 202, 206, 207*t*, 209, 212, 213, 225*t*, 235, 240, 277, 295, 303, 305*t*, 307*t*, 310, 315*t*, 331
- Clostridium*, 9, 10, 17*t*, 23*t*, 26*t*, 46, 46*f*, 47*t*, 75, 101, 140*t*, 160, 186, 199, 207*t*, 209, 211, 214, 215, 225*t*, 237, 240, 249, 262, 306, 307*t*
- coryneforms, 9, 72, 94, 95*t*, 98*t*
- Erwinia*, 9, 11, 138*t*, 140*t*, 141, 153, 160, 161*t*, 305*t*, 307*t*
- Escherichia*, 9, 23*t*, 77, 79, 129, 155, 229, 249
- gram negative, 8, 13, 28, 41, 56, 70, 73, 79, 95*t*, 102, 104, 105*t*, 106, 108, 122, 129, 153, 160, 168, 218, 251, 266
- gram positive, 8, 13, 28, 50, 94, 109, 126*t*, 129, 153, 155, 160
- Lactobacillus*, 9, 17*t*, 44, 47, 72, 74, 76, 81*t*, 90*t*, 91, 104, 105*t*, 106, 155, 170, 172, 197, 225*t*, 234, 236, 251, 263, 264*t*, 286, 296, 297, 304, 305, 306, 308
- Leuconostoc*, 9, 54, 90*t*, 153, 225*t*, 236, 251, 264*t*, 266, 269, 305*t*, 307*t*, 308
- Pseudomonas*, 9, 14, 17*t*, 23*t*, 26*t*, 48, 90*t*, 93, 95*t*, 97, 99*t*, 122*t*, 129, 138*t*, 140*t*, 143, 153, 154, 249, 305*t*, 307*t*, 310, 315*t*
- Staphylococcus*, 9, 23*t*, 76, 78, 191, 229, 239, 240, 291, 316*t*
- Streptococcus*, 9, 17*t*, 44, 74, 199, 234, 236, 306
- See also* Microbiological spoilage
- Bacterial diseases of plants, diagnosis of, 147
- Bactofugation, 55
- Baked eggs, 132
- Bakery products, 225–234
  - factors influencing spoilage, 227–228
  - food types and properties, 225–226
  - microbial sources and effects, 227
  - mold and yeast spoilage, 226–227
    - mycotoxin-induced health problems, 227
  - mycotoxins, categories, *see* Mycotoxins
  - white, filamentous, or “fuzzy” colonies, 226
  - mold-free shelf life of, 231 *f*
  - preservatives permitted, 230*t*
  - prevention and control of spoilage, 228–232
    - deep freezing, refrigeration, hot storage, 232
    - food irradiation, 229
    - good manufacturing practices/excellent sanitation programs, 228
    - heat-resistant laminated films, 228
    - heat treatments or ultraviolet (UV) irradiation, 229
    - humectants, to reduce water activity, 230
    - ionizing radiation or “cold pasteurization,” 229
  - MAP, 231
  - modification of headspace composition, 231
  - packaging in sterile atmosphere, 229
  - wrapping materials, 229
- rope spoilage, 233
  - characteristics, 233
  - environment for rope bacteria, 233
  - milling procedures, 233
  - ropiness, 233
  - types and numbers of microorganisms, 233
- sour spoilage, 234
  - bacterial metabolism of carbohydrates, 234
  - control and prevention, 234
  - treatments to prevent mold growth, 232 *f*
- See also* Cereal products
- Baking process, 132, 231, 233, 240
- Barrel-salted lumpfish roe, 106
- Basic Plant Pathology Methods*, 147
- BAX<sup>®</sup>, 205
- Beet sugar processing
  - flow diagram, 307 *f*
  - microorganisms associated, 307*t*
- Bergey's Manual of Systematic Bacteriology*, 276
- Beverages
  - bottled water, 246
    - detection/isolation of microorganisms, 249
  - factors affecting spoilage, 248
  - types and sources of microorganisms, 247–248
- carbonated beverages

- cold-filled preserved CSDs, 250–258
  - thermally processed non-preserved CSDs, 258–260
  - NCBs
    - ambient fruit juices, 276–279
    - chilled fruit and vegetable juices, 260–276
  - Bleaching processes, 272
  - “Bone taint,” *see* Meat products
  - Bottled water (drinking water), 246
    - categories of, 246
    - detection/isolation of microorganisms, 249
    - factors affecting spoilage, 248
      - visible mold spoilage, 249
    - treatments, 246–247
    - types and sources of microorganisms, 247–248
  - See also* Beverages
  - Bottlers
    - granulated sugar
      - mesophilic bacteria/molds/yeasts, 308
    - liquid sugar
      - mesophilic bacteria/molds/yeasts, 309
  - “12D botulinum cook,” 23
  - Brine chill systems, 74
  - Brined cheeses, 51
  - Brown or soft sugar, 304
  - “Buffer” or “poise,” 22
  - Butterfield’s buffer, 146
  - Butyric acid anaerobes, 211–212
- C**
- Camembert and blue-veined cheeses, 51
  - Cane sugar processing
    - flow diagram, 306*f*
    - microorganisms associated, 305*t*
  - Canned food regulation (CFR), 23, 24
  - Canned foods
    - autosterilization, 202, 205
    - cause of spoilage, 202–206
      - heating curves for thermal processes, 204*f*
      - heat shocking, 203
      - microbial characterization tools, 205
      - pH of any subculture media, 203
      - process establishment procedures, 204
    - factors, contributing to cause of spoilage, 189*t*
    - growth of acid-tolerant spore-forming microorganisms, 200–201
    - inadequate thermal processing, 198–200
      - “flat sour spoilage,” 199
      - reasons, 199
    - incipient spoilage (spoilage before processing), 190–192
    - non-microbial spoilage, 201–202
      - corrosion inside plain tinplate containers, 201
    - post-process contamination (leakage spoilage), 192–198
      - causes, 192–195
      - characteristics of, 195–196
      - control and prevention, 198
      - public health significance, 196–198
    - thermal process
      - products, causes for spoilage, 189–190
      - steps in establishment, 187*t*
    - thermophilic spoilage, 200
    - types of microorganisms
      - aciduric flat sour sporeformers, 212
      - heat-resistant molds, 216–217
      - mesophilic aerobic sporeformers, 206–209
      - mesophilic anaerobic sporeformers, 209–212
      - non-sporeformers, 217–218
      - presterilization, 213
      - thermal resistance, pH, and temperature requirements, 207*t*–208*t*
      - thermophilic anaerobic sporeformers, 214–216
      - thermophilic flat sour sporeformers, 213–214
      - water activity ( $a_w$ ), 188
  - Canning, 2, 82, 110, 148, 185, 186, 198, 200, 209, 214, 295
  - Carbonated soft drinks or CSDs, 249, 250, 251, 252, 253*t*, 254, 255, 256, 257, 258, 259
  - Carcass decontamination, 72
  - Catsup, *see* Ketchup
  - Caviar, 106, 107
  - Cephalopods, 97–98
  - Cereal products, 223–241
    - bakery products, 225–234
      - factors influencing spoilage, 227–228
      - microbial sources and effects, 227
      - mold and yeast spoilage, 226–227
      - mold-free shelf life of, 231*f*
      - preservatives permitted, 230*t*
      - prevention and control of spoilage, 228–232
      - rope spoilage, 233
      - sour spoilage, 234
      - treatments to prevent mold growth, 232*f*

- Cereal products (*cont.*)
- types of foods and general properties, 225–226
  - compound cereal products, 240–241
    - food types and properties, 240
    - spoilage and influential factors, 240
    - spoilage prevention and control, 241
  - dried cereal products, 237–239
    - food types and properties, 237–238
    - spoilage and influential factors, 238–239
    - spoilage prevention and control, 239
  - economic impact of spoilage, 223–225
  - shelf life of bread/cereal/pastry foods, 225*r*
  - methods for determination, 241–242
  - microbes involved in spoilage of, 225*r*
  - refrigerated dough and pasta products, 234–237
    - food types and properties, 234–235
    - spoilage and influential factors, 235–236
    - spoilage prevention and control, 236–237
- Cheddar cheese, 51
- Chemical oxidation–reduction (O/R), 7
- Chemical pasteurization, 291
- Chocolates
- cacao beans, 302
  - composition, 302
  - contamination, 304
  - critical control point (CCP) step, 302
  - examples of salmonellosis associated with, 303*r*
  - milk and dark, 302
  - pathogens, *Salmonella*, 303
  - post-thermal processing (post-roasting), 303
  - production, with processing steps, 303
- CIP systems, 250, 257, 271
- Citrate buffer, 270
- Clean-out-of-place (COP) cleaning, 274
- Clostridium*, 9, 10, 17*t*, 23*t*, 26*t*, 46, 46*f*, 47*t*, 75, 101, 140*r*, 160, 186, 199, 207*t*, 209, 211, 214, 215, 225*r*, 237, 240, 249, 262, 306, 307*t*
- Cocoa
- derived and composed of, 327
  - factors influencing, 340
  - microorganisms, types of, 335–336
    - fermentation process, 335
    - off-color and off-flavors, 336
    - potential vectors for contamination, 335
    - spoiled by molds, 336
    - sun drying and artificial drying, 336
    - prevention and control of spoilage, 344
    - production, 327
- Codex Alimentarius Commission (Codex), 203, 246
- Coffee, 327–328
- cherries, 328
  - peaberry, 328
  - factors influencing spoilage, 340
  - grown in Tropic of Cancer/Tropic of Capricorn, 327
  - microorganisms, types of
    - carcinogenic ochratoxin A, 336–338
    - dry processing, 336
    - earthy/musty/phenolic taints, 338
    - fermentation process, 337
    - fruity flavor and sour coffee, 338
    - onion flavor and rio flavor, 338
    - over-fermentation, “stinker beans,” 337
    - parchment coffee, 337
    - wet processing, 337
  - prevention and control of spoilage, 344
  - species for commercial use
    - robusto or canephora/arabica or arunga, 328
- Cold-filled preserved CSDs, 250–258
- carbonated soft drink production, 255*f*
  - carbonation tolerance, 252
  - detection/isolation of microorganisms, 258
  - factors affecting spoilage, 251–254
    - acetic acid bacteria, 254
    - lactic acid bacteria, 254
    - by yeasts, 251–254
  - fermentative yeasts causing spoilage of CSDs, 253*r*
  - prevention and control of spoilage, 254–257
    - ingredient and beverage properties, 254–256
    - pasteurization, 257
    - processing and manufacturing conditions, 256–257
    - returnable glass bottles (RGB), 257
    - types/sources of microorganisms, 250–251
    - lactic acid/acetic acid bacteria, 251
    - yeasts, 250
  - See also* Beverages
- Cold pasteurization, 25, 229
- Cold-smoked fish products, 102–104
- Cold smoking, 102, 103, 109
- Cold sterilization, 25, 229

- Coliform bacteria, 4, 9, 14, 41, 42*t*, 43, 47*t*, 50, 51, 54, 56, 81, 83, 146, 151, 152, 169, 241, 249, 342
- Colony counting procedures, 275
- Color Atlas of Post-Harvest Diseases and Disorders of Fruits and Vegetables*, A, 147
- Commercial egg processing, 127
- Commercially sterile foods, 52, 185, 186, 187*t*, 188, 189*t*, 192, 200, 202, 210, 212
- Commercial sterility, 23, 82, 83, 186, 187, 188, 259, 276
- "Compatible solutes," 16
- Compendium of methods for the microbiological examination of foods*, 123, 203, 214, 215, 217, 242, 331, 346
- Compositing techniques, 83
- Compound cereal products, 240–241
- food types and properties, 240
- influential factors of spoilage
- high-moisture fillings or toppings, 240
- refrigeration and shelf life control, 240
- prevention and control of spoilage, 241
- See also* Cereal products
- Contamination
- direct/indirect, 4
- sources of
- ecology of microbiological spoilage, 6
- human contamination of foods, 5
- postharvest contamination, 5
- preharvest contamination, water/soil, 4
- Cooked eggs, 130–131
- CO<sub>2</sub> packaging of fish, 101
- Corn starch processing
- steeping, enzymatic degradation step, 311
- wet milling, in liquid cyclone, 311
- Corn syrup or products, 313
- Coryneforms, 9, 72, 94, 95*t*, 98*t*
- Cosmetic corrosion, 201
- Cottage cheese, 51
- Crab products, 109
- Crustaceans, 97
- CSD production process, 254
- Cultured dairy products
- prevention and control of spoilage, 54–55
- bactofugation, 55
- cheesemakers, 54
- "green" or yogurt-like flavor, 54
- lactococci and leuconostocs, 54–55
- MAP of cheeses, 55
- pasteurization, 54
- proteolysis, 54
- solubilization of surfaces, 54
- sorbates and natamycin, 55
- Cut fruits and vegetables
- changes in fresh-cut lettuce, 150
- characteristics of microorganisms, 153–157
- gram-negative spoilage microbe, 155
- molds are fungi, 156–157
- visible mold growth on cut strawberry, 157
- detection and isolation, 168–169
- impact of microbiological spoilage, 149–150
- intrinsic and extrinsic factors, 157–161
- discoloration, 159*f*
- factors of spoilage, 161*t*
- pectolytic fluorescent pseudomonads, 160
- storage temperature and modified atmosphere, 159
- MAP, 147
- microbial populations and varieties, 152–153
- microbiological spoilage, 162–165
- aerobic bacterial populations, 163
- colony formation or visible microbial growth, 162, 162*f*
- formation of organic acids, 164
- pectolytic enzymes, 164
- prevention and control of spoilage, 165–168
- chemical technologies, 166
- cold chain temperature management, 168
- GMPs, 167
- nonthermal processing technologies, 166
- other factors, 166
- packaging, 167–168
- processing techniques, 166
- thermal processing, 165
- processing of, 147
- shelf life, 148–149
- sources of contamination, 150–152
- changes in mesophilic aerobic bacterial (TPC) and yeast, 152*f*
- "machinery mold" (*Geotrichum candidum*), 152
- Cuticle, 123–124, 125, 137, 144
- Czapek malt agar (CMA), 168
- D**
- Dairy products, 41–62
- consumption, survey of, 42
- detection and isolation, 56–61

Dairy products (*cont.*)

- American Public Health Association, 56
- fungi, conventional plating media, 61
- Grade A pasteurized milk ordinance
  - standard plate count limit, 56
- LATA or DRCM medium, 61
- MRS agar and APT agar, 61
- PCR-based detection methods, 61
- PCR-denaturing gradient gel electrophoresis, 61
- rapid genomic subtyping methods, RAPD/RFLP/AFLP, 61
- in RCM-lactate or BBMB-lactate medium, 61
- factors affecting spoilage, 50–51
  - cheeses, types, 51
  - fluid milk products, 51
- heat treatment standards in different countries, 53*t*
- increase in teat canal of milking cow, 49*f*
- methods for testing of, 60*t*
- microorganisms, *see* Microorganisms, in dairy products
- prevention and control of spoilage, 52–56
  - bactofugation, 55
  - carbonation, 52
  - cheesemakers, 54
  - cultured dairy products, 54–55
  - Grade A Pasteurized Milk Ordinance, 52
  - high hydrostatic pressure treatments, 53
  - in milk, 52–54
  - milk production in less sanitary conditions, 52
  - in other dairy products, 55–56
  - pasteurization, 54
  - proteolysis, 54
  - rapid cooling and quick use of raw milk, 52
  - removal of CO<sub>2</sub> before pasteurization, 53
  - treatments for pasteurization of milk, 54
  - Ultra-high-temperature (UHT) treatment, 52
  - Ultra-pasteurized milk products, 52
- types of, 41–42
  - cheese production, 42
  - factors influencing spoilage, 42
  - global dairy industry, 41
  - survey of consumption, 42
  - world milk production, 41

- and types of microorganisms, 42*t*
- DALs *see* Food defect action levels (DALs)
- “Dead ends,” 212
- “Defect rate,” 272, 273, 274
- Diacetyl reductase, 43
- Dichloran rose bengal chloramphenicol (DRBC) agar, 346
- DNase sequencing, 276
- Double seam, 192–196, 193*f*, 194, 195, 196, 198
- DRBC agar, *see* Dichloran rose bengal chloramphenicol (DRBC) agar
- Dried cereal products
  - food types and properties, 237–238
  - grain-based snack foods, 237
  - prepared dry mixes, 238
  - ready-to-eat grain-based foods, 237
  - “scratch” method, 238
  - spoilage and influential factors, 238–239
    - allergen-related ingredients, 238
    - baking or cooking process, 238
    - drying process, 239
    - flaking/puffing/extrusion, 238
    - ingredients used to manufacture, 238
    - raw cereal grains, 239
    - snack food industry, 238
    - sorbic acid, cake mixes, 239
  - spoilage prevention and control, 239
  - See also* Cereal products
- Dried eggs, 132
- Dried fish, 110–111
- Drum or tote filling systems, 268
- Dry salting process, 172
- DuPont RiboPrinter<sup>®</sup>, 205

## E

- Economic impact of spoilage
  - “low-carb” diets, 224
  - shelf life of bread, cereal, and pastry foods, 225*t*
  - staling of bread, 224
- Economic Research Service (ERS), 2
- Eggs and egg products
  - handling and storage conditions, 131*t*
  - liquid, 128–129
    - bacteria in liquid whole egg samples, 129
    - cholesterol-free egg, 128
    - pasteurization processes, 129–130
  - processed
    - baked eggs, 132
    - cooked eggs, 130–131
    - dried eggs, 132

- recommended egg and egg product handling and storage conditions, 131*t*
  - shell eggs
    - albumen, 125–126
    - bacteria associated with various types of egg spoilage or rot, 122
    - chitosan coating, 128
    - cuticle, 123–124
    - egg handling, 127–128
    - egg structure, parts of an egg, 123, 123*f*
    - membranes, 125
    - methods for detection, 123
    - microbial species from unwashed shell eggs, 122
    - pasteurization, 128
    - shell, 124–125
    - sources and types of microorganisms, 122–123
    - vitelline membrane, 126
    - yolk, 126
  - Electronic nose technology (e-nose), 32
  - Embden Meyerhof-Parnas (EMP), 252
  - EMP, *see* Embden Meyerhof-Parnas (EMP)
  - “Enteric” bacteria, 4, 9, 11, 12, 14, 16, 17, 79, 80, 81, 267, 269
    - See also* Microbiological spoilage
  - Enterobacteriaceae*, 9, 42, 58*t*, 71, 72, 75, 76, 79, 90*t*, 97, 99*t*, 102, 103, 106, 129, 153, 155, 169, 212, 267, 304
  - Enzymatic degradation, dairy products, 47–48
    - enzyme–substrate interactions, 48
    - extracellular proteases, 47
    - residual heat-stable microbial lipase, 48
    - thermally resistant proteases, 47
  - Equilibrium relative humidity (ERH), 15
  - ERS, *see* Economic Research Service (ERS)
  - Erwinia*, 9, 11, 138*t*, 140*t*, 141, 153, 160, 161*t*, 305*t*, 307*t*
  - Escherichia*, 9, 23*t*, 77, 79, 129, 155, 229, 249
  - ESL bottle treatment systems, 273
  - European Community’s Egg Marketing Regulations, 122
  - European Union (EU), 246
  - Evisceration, 72
  - “Extremophiles,” 10
  - Extrinsic factors to control spoilage
    - food plant sanitation, 30–31
    - modified atmosphere packaging, 29–30
    - nonthermal processes, 25–27
      - filtration, 27
      - high hydrostatic pressure, 26
      - high-intensity ultrasound, 26–27
      - ionizing irradiation, 25–26
      - pulsed electric fields, 26
      - sterilizing gases, 27
      - ultraviolet irradiation, 27
    - refrigeration, 27–29
      - by frozen storage, 28–29
      - by refrigerated storage, 28
    - thermal processes, 22–25, 23*t*
      - pasteurization, 24–25
      - sterilization, 23–24
      - thermal destruction of microorganisms, 22–23
    - vacuum packaging, 29
- F**
- “Father of Canning” (Appert, Nicolas), 185
  - FDA, *see* Food and Drug Administration (FDA)
  - Fermentation process, 335, 337
  - Fermentative metabolism, 7
  - Fermentative yeasts, 8, 11, 33, 161, 252, 253*t*, 261, 263, 264, 267, 276, 279
  - Fermented and acidified vegetable products
    - low pH/presence of organic acids, 169
    - microbiological and nonmicrobial spoilage, 171–172
      - cabbage, 171
      - cucumbers, 171
      - sauerkraut and kimchi, 172
    - prevention and control of spoilage, 173–173
  - Filling process, 263
  - “Film yeasts,” 8, 78, 171, 287
  - Filtration, 27, 263, 268
    - membrane, 258
  - Finfish, 98
  - Fish and seafood products
    - bacteria, raw finfish and crustaceans, 95*t*
    - global fish production from wild fish catches and from aquaculture (FAO), 88*f*
    - product categories and spoilage
      - cured seafood, 95–102, 102–108
      - heated seafood products, 108–110
      - raw, fresh seafood, 95–102
    - See also* Sea product categories and spoilage
    - raw materials for seafood products, 87
    - spoilage concepts, 88
      - amino acids/biogenic amines due to bacterial degradation, 92*t*
      - “belly burst,” 89

- Fish and seafood products (*cont.*)  
 chill storage fish spoilage, microorganisms, 93  
 fish muscle press juice inoculated with fish spoilage bacterium, 93*r*  
 fish substrates, 91–93  
 substrates and spoilage products/bacteria, 90*r*  
 taxonomy of spoilage bacterium, 93–94  
 utilization of fish catches, 88*f*
- Flat bottle, 217
- Flat sour spoilage, 196, 197, 199, 200, 207*t*, 212, 213, 214, 308, 331, 342
- “Flavor scalping,” 272
- Fluid milk products, factors affecting spoilage  
 psychrotrophic bacteria, 51  
 somatic cells in raw milk, 50
- Food and Drug Administration (FDA), 23, 186, 203, 246, 261, 270, 303, 329, 334, 341, 345, 346
- Food defect action levels (DALs), 345
- Food Guide Pyramid (MyPyramid), 3
- Food products, classification as per acidity, 186
- Food Pyramid, 136
- Foods and beverages  
 detection of microbiological spoilage  
 chemical methods, 32–33  
 microbiological methods, 32  
 organoleptic methods, 31–32  
 development of spoilage control measures  
 isolation of microorganisms, 33–34  
 predictive microbiology, 36  
 product challenge testing, 34–35  
 temperature monitoring during commercial distribution, 36  
 extrinsic factors to control microbiological spoilage  
 food plant sanitation, 30–31  
 nonthermal processes, 25–27  
 refrigeration, 27–29  
 thermal processes, 22–25  
 vacuum and modified atmosphere packaging, 29–30  
 food loss data  
 loss of US food supply from primary production through consumption, 3  
 Primary Weight column, 3  
 reasons for food loss, 3  
 intrinsic factors to control spoilage  
 chemical preservatives, 18–21  
 oxidation–reduction potential, 21–22  
 pH, 17–18  
 water activity, 15–17  
 microorganisms and mechanisms in spoilage  
 antagonisms, 13  
 ecology of microbiological spoilage, 6  
 means to characterize and differentiate, 6–8  
 mechanisms, 10–12  
 metabiosis, 14  
 microorganisms, 8–10  
 postharvest contamination, 5  
 preharvest contamination, 4  
 quorum sensing, 12–13  
 synergisms, 13–14
- Food spoilage molds, 8
- French dressing, 293, 294*r*  
*See also* Acidified specialty products
- Frozen fish, 110
- Fruits and vegetables  
 fermented and acidified, *see* Fermented and acidified vegetable products  
 fresh cut, *see* Cut fruits and vegetables  
 fresh whole, *see* Whole fruits and vegetables  
 future needs, 173–174
- Fruit-washing or sanitizing, 269
- Fungi  
 molds, 45  
 cream cheeses/heat-resistant molds, 45  
 “kerosene,” 45  
 vacuum-packaged cheeses, 45  
 yeasts  
 galactose-positive strains of yeasts, 44  
 low pH and the nutritional profile, 44
- G**
- GAPs *see* Good Agricultural Practices (GAPs)
- Gas chromatography, 32
- Gassiness in cheese, causes of, 47*t*
- Gassy Swiss cheese, 46*f*
- Genetics-based instrument, 206
- Germ theory, 185
- GHPs, *see* Good Hygienic Practices (GHPs)
- Global dairy industry, 41
- Glucose syrup, 309, 311
- GMPs, *see* Good Manufacturing Practices (GMPs)
- Good Agricultural Practices (GAPs), 136, 330
- Good Hygienic Practices (GHPs), 2, 167, 314
- Good Manufacturing Practices (GMPs), 2, 330
- Grade A Pasteurized Milk Ordinance, 52
- Gram negative bacteria, 8, 13, 28, 41, 56, 70, 73, 79, 95*t*, 102, 104, 105*r*, 106, 108, 122, 129, 153, 160, 168, 218, 251, 266



- Gram positive bacteria, 8, 13, 28, 50, 94, 109, 126*t*, 129, 153, 155, 160
- Grinding process, 346
- Guaiacol, 32
- Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables*, 136
- H**
- HACCP, *see* Hazard analysis and critical control point (HACCP)
- HACCP system, functions, 2
- "Halophile," 7
- Hazard Analysis and Critical Control Point (HACCP), 2, 319
- Health Canada, 246
- Heat-resistant molds, 200, 216–217, 258, 262, 276, 277
- Henderson–Hasselbalch equation, 19
- HHP, *see* High hydrostatic pressure (HHP)
- HHP, on dry foods, 26
- High glucose/fructose/maltose syrup, 311
- High hydrostatic pressure (HHP), 130
- High-intensity ultrasound, 26–27
- High-sugar products, 301–319
- chocolates, 302–304
  - confectionery, 317–319, 318*t*
  - honey, 314–317
  - sugars, 304–309
  - syrups, 309–314
- See also individual*
- High temperature, short time (HTST), 318
- Honey
- antibacterial activity, 317
  - American Academy of Pediatrics, 314
  - bacteriostatic/bactericidal factors, 317
  - composition, 314
  - "foul brood" or "American plague" disease of bees, 314
  - French, 314
  - Italian, 316
  - liquid and crystallized (granulated), 314
  - microbiological specifications for, 316*t*
  - microorganisms isolated from, 315*t*
  - osmophilic yeasts, 314
  - other microbes detected, 314–316
  - post-process contamination, 317
  - sterilization, 314
- Hot-fill-hold process, 276
- Hot-smoked fish, 109
- HTST, *see* High temperature, short time (HTST)
- "Hurdle effect," 21
- Hygienic package filling systems, 272
- I**
- Inadequate thermal processing, 198–200
- Incipient spoilage, 189, 190–192, 191, 202, 266, 267, 270, 291
- blending, 191
  - degree of, 190
  - spoilage pattern, 191
- Infrared techniques
- bulbs, 25
  - Fourier transform infrared spectroscopy, 33
  - heat treatment, 229
  - processing, 54
- International Code of Hygienic Practice For Tree Nuts, 343
- International Commission on Microbiological Specifications for Foods, 334, 335, 339, 341, 345, 346
- Intrinsic factors to control microbiological spoilage
- chemical preservatives, 18–21
    - benzoic acid, 20
    - carbon dioxide, 20
    - dimethyldicarbonate, 21
    - "hurdle effect," 21
    - methyl and propylparabens, 20
    - nisin, 20
    - potassium lactate and sodium diacetate, 20–21
    - propionic acid, 20
    - sodium bisulfite, 21
    - sodium nitrite, 20
    - sorbic acid, 19–20
    - spices and essential oils, 21
  - chemical properties of organic acids, 18–19
  - nonperishable or shelf stable, 15
  - oxidation–reduction potential (O/R potential or the Eh of the food), 21–22
  - perishable/semiperishable, 15
- pH, 17–18
- food pH values, 18*t*
  - influence of acidulant on minimum pH for growth of *Salmonellae*, 18*t*
  - microbial pH range for growth, 17*t*
  - properties and typical usage levels, 19*t*
  - water activity ( $a_w$ ) value, 15–17
    - influence of solute type, 17*t*
    - minimum  $a_w$  values to support growth of microorganisms, 16*t*
    - values of foods, 16*t*

- Invert syrup, inversion techniques, 310
- Ionizing irradiation, 25–26  
 “cold sterilization” or “cold pasteurization,”  
 25  
 ionizing irradiation *d* values of  
 representative organisms, 26*t*  
 rad (unit of radiation energy), 25
- Irradiation process  
 electron beam, 54  
 gamma, 154, 341, 342  
 ionizing, 25–26  
*See also* Ionizing irradiation  
 ultraviolet, 24, 27, 229, 247,  
 255, 313
- K**
- Ketchup, 286, 288, 295  
*See also* Acidified specialty products
- Koch’s postulates, 34
- L**
- LAB, *see* Lactic acid bacteria (LAB)
- Laboratory Guide for Identification of Plant  
 Pathogenic Bacteria*, 147
- Lactic acid bacteria, 43–44, 251  
 buttermilk/sour cream, 43  
 catabolism in amino acids in cheese, 43  
 cheddar and colby cheeses, 44  
 facultative *Lactobacilli*, 43  
 heterofermentative lactic acid bacteria, 43  
*Lactobacilli* and *Leuconostoc*, 43  
 off-flavors and gas in ripened cheeses,  
 43  
 residual galactose in cheese, 43  
*Lactococci*, 43  
 metabolism of tyrosine, *Lactobacilli*, 44
- Lactic acid bacteria (LAB), 169
- Lactobacillus*, 9, 17*t*, 44, 47, 72, 74, 76, 81*t*,  
 90*t*, 91, 104, 105*t*, 106, 155, 170,  
 172, 197, 225*t*, 234, 236, 251, 263,  
 264*t*, 286, 296, 297, 304, 305, 306,  
 308
- Leakage spoilage, 189, 190, 192, 195, 196
- Leuconostoc*, 9, 54, 90*t*, 153, 225*t*, 236, 251,  
 264*t*, 266, 269, 305*t*, 307*t*, 308
- Liquid egg products, 128–129  
 bacteria in liquid whole egg samples, 129  
 cholesterol-free egg, 128  
 pasteurization processes, 129–130  
 conventional, 129  
 egg yolks, 130  
 pulsed electric fields (PEFs), 130  
 thermal processing, 130  
 “ultrapasteurization,” 129
- Liquid sugar, 310
- Low-acid foods, 186
- M**
- Macroautophagy, 252
- Malt Extract Agar (MEA), 297
- Man, Rogosa and Sharpe (MRS)  
 agar, 168
- Maple sap, spoilage defects  
 green/milk/red/ropy sap, 310
- Maple syrups, 309
- MAP *see* Modified Atmosphere Packaging  
 (MAP)
- Mayonnaise, 287–289  
*See also* Acidified specialty products
- Meat products, 70  
 bacon, 77–78  
 canned meat products, 75  
 “leaker” spoilage, 75  
 cured and uncured ready-to-eat products,  
 73–74  
 additional agents, 73  
 brine chill systems, 74  
 “heterofermentative,” 73  
 “homofermentative,” 74  
 fermented and dried products, 76–77  
 fresh, refrigerated raw meat products,  
 71–72  
 raw/intact, shelf life, 71, 72  
 raw/refrigerated ground/minced, shelf  
 life of, 72  
 meat spoilage microflora, 70  
 microbiological testing methods, 83  
 mitigating factors against spoilage, 69–70  
 molecular genetic techniques, 83  
 organic meat products, 78  
 perishable salted and cured meat products,  
 72–73  
 vacuum and modified atmosphere-  
 packaged products, 75–76  
 variety meat products (offal), 78–79
- Mechanical refrigeration systems, 2
- Mechanisms, food spoilage, 10–12  
 amylolytic enzymes, 12  
 digestion of complex carbohydrates, 11  
 guaiacol production, 12  
 lipolysis, 12  
 oxidation of organic acids and  
 alcohols, 12  
 protein hydrolysis, 11  
 spoilage characteristics, 11  
 sugar fermentation  
 with acid production, 11

- with gas production, 11
- surface growth, 12
- Mesophilic anaerobic sporeformers, 209–212
  - butyric acid anaerobes, 211–212
  - putrefactive anaerobes, 209–211
- Metabiosis, 13, 14, 104, 197
- Methods for the Diagnosis of Bacterial Diseases of Plants*, 147
- Microaerophilic, 7
- Microbiological spoilage
  - associations between groups
    - antagonisms, 13
    - metabiosis, 13, 14, 104, 197
    - synergisms, 13–14
  - means to characterize and differentiate, 6–8
    - ability to form endospores, 7
    - gram stain, 6–7
    - “halophile,” 7
    - morphology, 6
    - “osmophile,” 7
    - oxygen relationships, 7
    - pH relations, acidophiles/acidurics, 8
    - temperature relationships, 7
    - type of metabolism, fermentative/oxidative, 7
  - water relations,
    - xerotrophic/osmotolerant, 8
  - microorganisms involved in
    - Alicyclobacillus* species, 10
    - Bacillus* species, 10
    - Clostridium* species, 10
    - coryneforms, 9
    - Enterobacteriaceae*, 9
    - “film yeasts,” 8
    - lactic acid bacteria, 9
    - means to characterize and differentiate, 6–8
    - Micrococcaceae*, 9
    - molds, 8
    - Neisseriaceae*, 9
    - Pseudomonadaceae*, 9
    - spore-forming bacilli, 9–10
    - yeasts, fermentative/oxidative, 8
- Micrococcaceae*, 9
- Micro-ID<sup>®</sup>, 205
- Microorganisms, in dairy products
  - Enterococcus faecalis* subsp. *liquefaciens*
    - spoilage in Swiss cheese, 47
  - Eubacterium* sp., a facultative anaerobe
    - spoilage in gassiness in Cheddar cheese, 47
  - sources of, 48–50
    - contamination of dairy products, 50
    - contamination of raw milk, 48–50
    - types of, 42–48
  - See also* Dairy products
- Milk, prevention and control of spoilage, 52–54
  - carbonation, 52
  - carbon dioxide to milk and milk products, 52
  - Grade A Pasteurized Milk Ordinance, 52
  - high hydrostatic pressure treatments, 53
  - milk production/in less sanitary conditions, 52
  - rapid cooling and quick use of raw milk, 52
  - removal of CO<sub>2</sub> before pasteurization, 53
  - treatments for the pasteurization of milk, 54
  - ultra-high-temperature (UHT) treatment, 52
  - ultra-pasteurized milk products, 52
- Milling process, 233
- Mineral water, 246
- “Minimum public health” process, *see* Canned foods
- Modified Atmosphere Packaging (MAP), 55, 75–76, 80, 81t, 147, 148, 149, 150, 153, 154, 156, 159, 160, 161t, 164, 167, 173, 174, 231
- Molds
  - Alternaria*, 142t, 262, 339
  - Aspergillus*, 266, 315t, 330, 336
  - Fusarium*, 139t, 142t, 225t, 226, 262, 329
  - Geotrichum*, 44, 139t, 142t, 152, 262, 268
  - heat-resistant, 216–217
    - methods for identifying, 217
    - soil and dust, 217
  - Mucor*, 139, 268
  - Penicillium*, 45, 50, 55, 108t, 139t, 141, 225t, 262, 263, 264t, 287, 297t, 315
  - Rhizopus*, 139t, 142t, 225t, 262, 339
- Molecular genetic methods, 83
- Mollusks, 95
- Mucilage, 328, 337, 338, 340, 344
- Mushroom wash systems, 145
- Mustard, 296
- Mycoderma*, *see* Oxidative yeast
- Mycotoxins
  - in cereal products
    - aflatoxin, 226
    - DON, or vomitoxin, 226
    - fumonisin, 226
    - other fungal toxins, 226
  - See also* Bakery products

- N**
- NACMCF, *see* National Advisory Committee on Microbiological Criteria for Foods (NACMCF)
- National Advisory Committee on Microbiological Criteria for Foods (NACMCF), 188
- National Cancer Institute, 136
- National Canner's Association, 214
- National Food Processors, 195
- NCBs, prevention and control of spoilage, 269–275
- application of pasteurization processes, 270–271
  - high-quality juice ingredients, selection/use, 269–270
  - hygienic package filling systems, 272–274
  - pasteurized juice delivery systems, 271
  - refrigeration of packaged juice, 274–275
  - sanitary packaging materials, 271–272
- Nectar harvested by bees, 314
- Neisseriaceae*, 9
- Nisin, 214
- Non-carbonated beverages (NCBs)
- ambient fruit juices, 276–279
    - additional tests for presence of *Alicyclobacilli*, 277, 279*t*
    - Alicyclobacilli*, characteristics, 277–279, 277*t*
    - heat-resistant molds, 277
    - methods for detection/identification of microorganisms, 275–276
  - chilled fruit and vegetable juices, 260–276
  - APP technology, 274
  - factors affecting juice spoilage potential/rates, 261–269
  - gable-top cartons, criteria for, 271
  - juice-packaging materials, 263
  - mold genera responsible for spoilage, 262
  - pH values and the naturally occurring organic acids of fruit juices, 261*t*
  - prevention and control of spoilage, 269–275
  - spoilage defects in chilled juices, 264*t*–265*t*, 268*t*
  - types and sources of microorganisms, 261–267
- See also* Beverages
- Non-sporeformers, 217–218
- Normal corrosion, 201
- Nuts, 326–327
- cultivation, 326
  - enhancement and improvement of quality, 327
  - factors influencing, 339–340
    - International Programme on Chemical Safety, 339
    - nut crop damage directly or indirectly, 339
    - thermal or nonthermal process, 340
  - microorganisms, types of, 334–335
    - chopping and slicing, 334
    - field/mold/bacterial contamination, 334
    - hazelnuts, 335
    - International Commission on Microbiological Specifications for Foods, 334
    - mechanical methods of drying, 334
    - mold decomposition/growth, 335
    - predominant mold, 335
  - prevention and control of spoilage, 343–344
    - dry roasting, oil roasting, and blanching, 343
    - International Code of Hygienic Practice For Tree Nuts, 343
    - thermal and nonthermal treatments, 343
  - protection against coronary disease and cancer, 327
  - tree nuts and peanuts, 326
- O**
- “Obligate aerobe,” 7
- See also* Microbiological spoilage
- “Obligate anaerobe,” 7, 8, 10, 28, 108, 215, 287, 289
- Organoleptic methods for spoilage detection
- odor, 31
  - taste, 32
  - visual, 31–32
- “Osmophile”, 7
- Osmophilic yeasts and molds, 8, 16, 42*t*, 235, 236, 239, 256, 267, 289, 301, 313, 314, 316, 317
- “Osmotolerant,” 8, 9, 10, 16, 227, 228, 239, 241
- Oxidation–Reduction Potential, 7, 21–22, 267
- Oxidative metabolism, 7, 8
- Oxidative yeast, 8, 12, 14, 289, 290, 291
- Oxygen transmission rate (OTR), 154, 157, 162
- P**
- Packed, fresh fish, 101–102
- Partition coefficient (PC), 19, 20, 289

- Pasteurization, 24, 45, 46, 50, 52, 53*t*, 55, 56, 147, 170, 172, 258, 259, 261, 262, 268, 269, 273, 275, 277, 294, 295  
 acidified specialty products, 288  
 atmospheric steam pasteurization in container, 25  
 bakery products, 229  
 chemical, 291  
 cold-filled preserved CSDs, 257  
 combinations of time and temperature required for the pasteurization of milk, 24*t*  
 dairy products, 54  
 eggs and egg products, 129–130  
 hot-fill processes, 24  
 milk, 24*t*, 54  
 NCBs, 270–271  
 shell egg, 128
- Pasteurized juice delivery systems, 271
- Pasteurized Milk Ordinance, 24
- PCAC, *see* Plate count agar with chloramphenicol (PCAC)
- PCR-based detection methods, 61
- Pectin methyl esterase (PME), 269
- PEFs, *see* Pulsed electric fields (PEFs)
- PET, *see* Polyethylene terephthalate (PET)
- Pinking, 108, 149, 150
- Pitting corrosion, 201–202
- Plant defense responses, 174
- Plant pathology methods, 147
- Plate count agar (PCA), 168
- Plate count agar with chloramphenicol (PCAC), 346
- Plating methods, 61, 217  
 conventional laboratory, 61
- PME, *see* Pectin methyl esterase (PME)
- Polyethylene terephthalate (PET), 278
- Post-process contamination, 192–198, 218, 227, 317
- Poultry and poultry products  
 cooked RTE cured and uncured, 82–83  
 factors, mitigate against bacterial spoilage, 69–70  
 further processed poultry, 81–82  
 mechanically deboned, 81  
 generic process flow, 80*f*  
 microbiological profiles of refrigerated raw products, 79–81  
 microbiological testing methods, 83  
 microorganisms in spoiled refrigerated pack, 80*t*  
 microorganisms isolated from chicken carcasses, 80*t*  
 molecular genetic techniques, 83
- Pourable salad dressings, requirements, 293–295  
*See also* Acidified specialty products
- Predictive microbiology, 36
- Preharvest contamination, 4
- Pressure balancing systems, 263
- Presterilization, 213
- Primary Weight column, 3
- Procedures for diagnosis of spoilage*, 203
- Profile of selected imported and domestic spices, 332–333*t*
- Pseudomonads, 4  
*See also* Contamination, sources of  
*Pseudomonas*, 9, 14, 17*t*, 23*t*, 26*t*, 48, 90*t*, 93, 95*t*, 97, 99*t*, 122*t*, 129, 138*t*, 140*t*, 143, 153, 154, 249, 305*t*, 307*t*, 310, 315*t*
- Psychrotrophs, 7, 7, 42–43, 42*t*, 47, 59*t*, 72  
 bacteria in raw milk, 42  
 gram-negative psychrotrophic bacteria, in cottage cheese, 43  
 limit the shelf of cottage cheese, 43  
*See also* Microbiological spoilage
- Pulsed electric fields (PEFs), 26, 130
- Purified water, 246
- Putrefactive anaerobes, 209–211
- Q**
- Quorum sensing, 12–13  
*N*-Acyloxymoserine lactones (AHLs), 13
- R**
- Rad (unit of radiation energy), 25
- Rapid chilling, 72
- Rapid detinning, 201
- Raw milk pasta filata cheeses, 51
- Ready-to-drink (RTD) beverages, 245
- Recommended international code of hygienic practice for low and acidified low acid canned foods*, 203
- Red meat, predominant microflora of, 71
- Refrigerated dough and pasta products, 234–237  
 food types and properties, 234–235  
 chemically leavened refrigerated doughs, 235  
 proliferation of packaged refrigerated dough product, 235  
 refrigerated distribution methods, 235  
 prevention and control of spoilage, 236–237  
 gas-impermeable containers, 237

- Refrigerated dough and pasta products (*cont.*)  
 lactic spoilage of refrigerated doughs, 236  
 refrigerated cookie dough, 236  
 spoilage and influential factors, 235–236  
 alcoholic/fruity/acetone, 235  
 fruit-filled products, 235  
 heterofermentative (gas producing), 236  
 homofermentative (nongas producing), 236  
 ingredients, 235  
*See also* Bakery products; Cereal products
- Refrigeration food preservation  
 by frozen storage, 28–29  
 formation of ice crystals during freezing, 28  
 vegetables, 29
- Regulatory standards for indicator organisms  
 in different countries, 57–59*t*
- RiboPrinter<sup>®</sup>, 205, 206
- “Rio flavor,” 338
- Ripening, 43, 48, 51, 54, 55, 77, 97, 97, 107, 144, 166
- Roasting, 302–304, 336–338, 343
- S**
- Salad dressing formulation, 292, 292*t*  
*See also* Acidified specialty products
- Salmonella*, 18*t*, 23*t*, 26*t*, 122, 125, 127, 128, 129, 130, 131, 151, 188, 196, 229, 239, 270, 291, 302, 303, 315, 316*t*, 346
- Salted, cold-smoked fish, 102–104
- Salted fish, fungal spoilage of, 108*t*
- Sanitation in Food Processing (Second ed.)*, 31
- Sauerkraut, 9, 14, 169, 171, 172, 286
- Sea product categories and spoilage  
 biogenic amines of bacteria isolated from spoiled cold-smoked salmon, 105*t*  
 cured seafood  
 caviar, 106, 107  
 fungal spoilage of heavily salted fish, 107–108, 108*t*  
 other lightly preserved seafood products, 104–106  
 pinking, 108  
 ripened anchovies, 106  
 salted, cold-smoked fish, 102–104  
 semi-preserved seafood products, 106–107  
 heated seafood products  
 crab products, 109  
 fully canned products, 110  
 hot-smoked fish, 109  
 sous vide-cooked fish, 109  
 miscellaneous  
 dried fish, 110–111  
 frozen fish, 110  
 surimi, 110  
 raw, fresh seafood  
 bivalve mollusks, 95  
 cephalopods, 97–98  
 changes in composition of microflora during storage, 99*t*  
 CO<sub>2</sub> packaging, 101  
 crustaceans, 97  
 finfish, 98  
 indole formation in shrimp/prawns, 98*t*  
 packed, fresh fish, 101–102  
 shelf lives of seafood products, 96*t*  
 Seltzer, 246  
 Semipreserved seafood products, 106–107  
 Sequential synergisms, 14  
 Shelf-stable salted, 77  
 Shell eggs  
 albumen, 125–126  
 bacteria associated with egg spoilage or rot, 122  
 chitosan coating, 128  
 cuticle, 123–124  
 detection of spoilage, 123  
 egg handling, 127–128  
 egg structure, parts of an egg, 123, 123*f*  
 membranes, 125  
 microbial species from unwashed shell eggs, 122  
 shell, 124–125  
 sources and types of microorganisms, 122–123  
 vitelline membrane, 126  
 yolk, 126  
 Shrimp/prawns, indole formation in, 98*t*  
 Siderophores, 13, 143  
 Slime (dextran) formation, 71, 74, 81, 88, 307, 318  
 Soda water, 246  
 Sodium metabisulfite (H<sub>2</sub>S<sub>2</sub>O<sub>5</sub>), 21  
 Soft drinks, 246, 249, 250, 252, 254, 255*f*  
 Soft or unripened cheese, 42, 43, 51, 55, 58*t*, 61  
 Soft-rot, 149, 154, 159, 160, 162, 164, 165  
 bacteria, 141, 338  
*Erwinia*, 143  
 occlusion, 155  
 “Sous vide” (under vacuum) technology, 109  
 Sparkling water, 246, 247, 248, 250

- SPC, *see* Standard plate counts (SPC)
- Spices, 325–326
- derived from, 325
  - factors influencing, 338–339
  - maximum moisture levels, 329 $r$
  - prevention and control of spoilage, 340–342
    - Code of Hygienic Practice for Spices and Dried Aromatic Plants, 340
    - Codex Alimentarius Commission, 340
    - irradiation with gamma rays, 341
    - Transport Information Service, guidelines, 341
    - US Environmental Protection Agency, 342
  - top twelve spices consumed in the US in 2000, 326 $r$
  - types of microorganisms, 325–326
    - bacterial spoilage, 330
    - field fungi, 329, 330
    - GAPs/GMPs, 330
    - lactic acid bacteria, 331
    - storage molds, 329, 330
    - thermophilic sporeformers, aerobic/anaerobic, 331
    - treatment options, 334
    - yeasts like molds, 330
- See also* Spices/nuts/cocoa/coffee, spoilage detection methods
- Spices/nuts/cocoa/coffee, spoilage detection methods, 345–346
- macroanalytical examination, 345
    - DALs, 345
    - in-shell and shelled nuts, 345
  - microbiological examination, 345–346
    - Compendium of Methods for the Microbiological Examination of Foods*, 346
    - Dichloran 18% glycerol (DG18) agar, 346
    - DRBC agar, 346
    - International Commission on Microbiological Specifications for Foods, 345
    - PCAC, 346
    - TGYC agar, 346
    - US Food and Drug Administration's *Bacteriological Analytical Manual*, 346
- Spoilage control measures, development of isolation of microorganisms in spoilage incidents, 33–34
- Koch's postulates, 34
  - predictive microbiology, 36
  - product challenge testing, 34–35
    - Accelerated Shelf Life Testing (ASLT), 35, 35 $r$
    - inoculation of test samples, 34–35
    - predictive microbiology, 36
    - temperature monitoring during commercial distribution, 36
    - time–temperature indicators (TTIs), 36
- Spoonable salad dressings, 291–293, 292 $r$
- See also* Acidified specialty products
- Spore-forming bacteria in dairy products, 45–47
- “flat sour” defect in canned milk products, 46
    - gassing, Swiss cheese, 46
    - thermoduric and thermophilic, 46
- Spring water, 245, 246
- Staining, 6, 147, 202
- “Staling,” 224, 226, 232
- Standard methods agar (SMA), 168
- Standard plate counts (SPC), 342
  - for ETO-treated and -untreated spices, 342 $r$
- Staphylococcus*, 9, 23 $t$ , 76, 78, 191, 229, 239, 240, 291, 316 $r$
- Starch-based syrups, 311
  - acid-enzyme process, 311
  - acid process, 311
  - multi-enzyme process, 311
- Sterile food systems, 89
- Sterilization, 148, 199, 215, 271, 273, 276, 297, 314
  - concept of commercial sterility, 23
  - “12D botulinum cook,” 23
  - low-acid canned food regulation (CFR), 23, 24
  - sterile foods, 24
  - UHT-sterilized food, 24
- Sterilizing gases, 27
- Streptococcus*, 9, 17 $t$ , 44, 74, 199, 234, 236, 306
- Sugar
  - “bottlers” granulated sugar
    - mesophilic bacteria/molds/yeasts, 308
  - “bottlers” liquid sugar, 308–309
    - mesophilic bacteria/molds/yeasts, 309
  - brown or soft sugar, 304, 313 $r$
  - confectionery products
    - control of microbial contaminants, 319
    - HACCP program, 319
    - HTST, 318
    - source of microorganisms, 319
  - dextrose or D-glucose, 304

- Sugar** (*cont.*)
- imidodisulfonate cocrystallization, 308
  - National Canners Association, 308
  - purified crystallized sucrose, 304
  - slime (dextran) formation, 307
  - spoilage microorganisms detected in, 313*t*
  - from starch
    - steps associated with product of, 312*f*
  - sugar beets, 304, 305, 306
  - sugarcane, 304
  - syrups
    - liquid sugar, 309
    - starch-based syrups, 309
    - tree saps, 309
- Sugar beets** (*Beta vulgaris*), 304, 305, 306
- Sugarcane** (*Saccharum officinarum*), 304, 305
- bacterial content (range) of, 305*t*
- Sulfide stinker spoilage**, 214
- Surimi**, 96*t*, 110
- Synergisms**, 13–14
- Syrups**
- corn starch processing
    - steeping, 311
    - wet milling, in liquid cyclone, 311
  - corn syrup or products, 313
  - glucose syrup, 309
  - high fructose/glucose/maltose syrup, 311
  - invert syrup, inversion techniques, 310
  - liquid sugar, 310
  - maple sap, 310
  - maple syrups, 309
  - osmophilic yeasts and molds, 313
  - post-thermal processing, 311
  - prevention and control of spoilage, 313, 314
  - sanitizing processing equipment, 310
  - starch-based syrups, 311
    - acid-enzyme process, 311
    - acid process, 311
    - multi-enzyme process, 311
  - sugar syrups
    - liquid sugar, 309
    - starch-based syrups, 309
    - tree saps, 309
  - UV irradiation, 313
- T**
- Tetra Pak Processing Systems**, 269
- TGYC agar**, *see* Tryptone glucose yeast extract chloramphenicol (TGYC) agar
- Thermally processed non-preserved CSDs**, 258–260
- detection/isolation of microorganisms, 259–260
  - factors affecting spoilage, 259
  - prevention and control of spoilage, 259
  - types and sources of microorganisms, 258–259
- See also* Beverages
- Thermal processes**, 22, 25, 165, 186, 187, 188, 200, 204, 209, 210
- Thermal resistance, pH, and temperature requirements**, 207*t*–208*t*
- Thermophilic anaerobic sporeformers**, 214–216
- non-H<sub>2</sub>S gas producers, 215–216
  - sulfide “stinkers,” 214–215
- Thermophilic flat sour sporeformers**, 213–214
- ThermoSafe system**, 165
- Tonic water**, 246
- Torry Research Station**, 93
- “Total acidurics,”** 275
- Tree nuts**, 3*t*, 326, 339
- Triggering host defense systems**, 13
- Tryptone Glucose Yeast Extract Agar (TGYA)**, 297
- Tryptone glucose yeast extract chloramphenicol (TGYC) agar**, 346
- U**
- UHT**, *see* Ultrahigh temperatures (UHT)
- UHT-sterilized food**, 24
- Ultrahigh temperatures (UHT)**, 24, 47, 48, 52, 53*t*, 58*t*, 59*t*, 209
- “Ultrapasteurization,”** 129
- Ultrasound, high-intensity**, 26–27
- Ultraviolet irradiation**, 24, 27
- United States Department of Agriculture (USDA)**, 2, 186
- USDA**, *see* United States Department of Agriculture (USDA)
- USDA Food Safety and Inspection Service (USDA-FSIS)**, 78, 186
- USFDA**, *see* US Food and Drug Administration (USFDA)
- USFDA Bacteriological analytical manual**, 203
- US Food and Drug Administration (USFDA)**, 246
- UV installations in ventilation**, 27
- V**
- Vacuum and modified atmosphere packaging**, 29–30, 55, 75, 77, 79, 161
- “Vascular wilt,”** 155
- Vegetable(s)**
- and fruits, *see* Fruits and vegetables



- products, fermented and acidified. *see*  
 Fermented and acidified vegetable  
 products
- Ventilation systems in food processing plants,  
 6
- Vinegar, 296–297, 297*t*  
*See also* Acidified specialty products
- Vitek<sup>®</sup>, 205
- W**
- Water activity ( $a_w$ ) value, 6, 7, 8, 9, 10, 14,  
 15–17, 21, 35, 36, 41, 51, 56, 61,  
 71, 72, 89, 110, 130, 132, 154, 167,  
 172, 185, 186, 188, 217, 224, 226,  
 228, 230, 231, 233, 235, 236, 238,  
 239, 240, 241, 256, 267, 268*t*, 270,  
 277*t*, 288, 289, 292, 313, 314, 316,  
 317, 328, 330, 334, 335, 338, 339,  
 340, 343, 344, 346
- “Weibull hazard analysis,” 36
- Well water, 195, 246, 255
- Wet process, 336, 337
- Whole fruits and vegetables, 135–137  
 characteristics of microorganisms, 137–143  
   bacterial fruit pathogens, 138*t*  
   bacterial vegetable pathogens, 140  
   extensive *blue* mold infestation on  
   apples, 141*f*  
   external damage, 138  
   fungal fruit pathogens, 139  
   fungal vegetable pathogens, 142*t*  
   GAP, biochemical tools required,  
   136–137  
   soft-rot bacteria, 141  
   “soft-rot erwinia,” 143  
 detection/isolation of microorganisms,  
 145–147  
 agitation by a wrist-action shaker, 146  
*Basic Plant Pathology Methods*, 147  
 blending the sample, 146
- Laboratory Guide for Identification of  
 Plant Pathogenic Bacteria*, 147  
*Methods for the Diagnosis of Bacterial  
 Diseases of Plants*, 147  
 pulsifier, 146  
 sterile, deionized water, 146
- GAPs, categories, 136–137
- prevention and control of spoilage  
 aerial fungicide applications, 144  
 forced air refrigeration, 145  
 immersion in ice, 145  
 methods for monitoring sanitizer  
   concentration, 145  
 minimizing wounds and bruising, 144  
 postharvest factors, 145  
 preharvest and harvest factors, 143–144  
 sanitizing chemical in produce industry,  
 145  
 vacuum cooling, ice, 145
- Wind-borne mold spores, 4
- World Health Organization (WHO), 4, 246,  
 248
- World milk production, 41
- X**
- “Xerotrophic,” 8, 16*t*
- Y**
- Yeast, 17*t*, 42*t*, 47*t*, 71, 76, 80*t*, 156, 161*t*, 227,  
 250, 251, 297*t*, 308, 309, 315, 316,  
 332*t*, 333*t*  
 fermentative, 8, 11, 33, 161, 252, 253*t*, 261,  
 263, 264*t*, 267, 276, 279  
 fermented fruit juices, 296  
 osmophilic, 314  
 oxidative, 8, 12, 14, 289, 290, 291
- Z**
- “Zapatera” spoilage, 171