

# Index

*Note:* Italicized *b*, *f* and *t* refer to boxes, figures and tables, respectively.

- academia, 27–8  
 academic institutions, 313  
 accelerated shelf life testing (ASLT), 100–101  
 acidity, 90  
 acrylamide, 84  
 adulteration, 39, 84–5  
 advocacy groups, 28  
 aflatoxin, 79, 102, 103*t*  
 aflatoxin B1, 41*t*  
 Africa, food trade, 31*t*  
 airplane, relative efficiency of, 37*t*  
 alfalfa sprouts, contamination of, 18*t*  
 Algeria, food trade, 31*t*  
 allergens, 78–9. *See also* chemical hazards  
   additions to prerequisite programmes, 52  
   control of, 117–18, 295  
   in high-risk food ingredients, 103*t*  
   as intrinsic ingredient, 296*t*  
   labelling requirements, 160*t*  
   regulated, 40*t*  
   regulations, 40  
 alternative energy sources, 35–6, 313  
 ammeline, 84  
 ammelide, 84  
 amnesic shellfish poisoning, 80  
*Anisakis simplex*, 78*t*  
 antibiotics, 81  
 apple juice, 68*t*  
 aqueous ingredient, 116  
 arable land, 34  
 Argentina, food trade, 31*t*  
 arsenic, 83  
*Ascaris lumbricoides*, 78*t*  
 Asia–Pacific, food trade, 31*t*  
*Aspergillus*, 79  
*Aspergillus flavus*, 79  
 audit, 229. *See also* food safety management  
   auditor competency, 43  
   checklist, 231–2  
   criteria, 229  
   evidence, 229  
   findings, 229  
   global food safety audit standards, 42–3  
   organisations, 313  
   questions used in, 231  
   shared, 45  
   supplier, 44–5  
 auditee, 230  
 auditors, 43  
   elements of competence, 230*f*  
   skills, 230  
 Australia, food trade, 31*t*  
 automobile, relative efficiency of, 37*t*  
  
*Bacillus cereus*, 68*t*, 70*t*, 72*t*, 73, 103, 109*t*, 113*t*,  
   304  
*Bacillus coagulans*, 109*t*  
*Bacillus stearothermophilus*, 109*t*  
 bacterial infections, 66*t*  
 bacterial pathogens, 72–4  
   emerging pathogens, 72–3  
   growth limits, 72*t*  
   non spore-forming, 73–4  
   sources of, 71*t*  
   spore-forming, 73  
 bait stations, 168*b*  
 barcode scanning, 291*t*  
 Bauman, Howard, 5  
 benzene, 16*t*  
 berry, 68*t*  
 best practice programmes, 129  
 biodiesel, 36  
 biofuels, 36, 59  
 biological hazards, 66–78. *See also* chemical  
   hazards; physical hazards  
   bacterial pathogens, 73–5  
   epidemiological data, 66–9  
   foodborne illnesses, 69–73

- biological hazards (*Cont.*)  
 in home kitchen, 304  
 morbidity statistics, 66–9  
 parasitic worms, 78  
 prions, 76–7  
 process control of, 106–17  
 destruction of microorganisms, 106–12  
 prevention of contamination, 114–17  
 prevention of microbial growth, 112–14  
 protozoan parasites, 77–8  
 viral pathogens, 75–6
- bird control, 168*b*
- blast chilling, 290*t*
- blue water, 35
- bottled water, contamination of, 16*t*
- Botulinum toxin, 16–17*t*
- botulism, 67*t*, 69, 95
- bovine spongiform encephalopathy (BSE), 77
- brand, protection of, 12
- Brazil  
 food trade, 31*t*  
 labour cost in, 33*t*
- BRC Global Standard, 232–3
- breakfast cereal, contamination of, 16*t*
- British Retail Consortium Global Standard for Food Safety, 42
- brittle plastic, 119
- business continuity planning, 45–6
- cadmium, 83
- cake mixes, 4
- calibration records, 227
- Campylobacter jejuni*, 71–2*t*, 74, 113*t*
- Campylobacter* spp., 25, 68*t*
- Canada, food trade, 31*t*
- canning industry, 7
- canning processes, 109
- carbon dioxide, 94, 114
- Cargill Inc., 46
- Carrefour, 42
- carrot juice, 68*t*  
 contamination of, 17*t*
- case studies  
 food service, 293–301  
 HACCP control chart, 301*t*  
 HACCP study, 297  
 HACCP team, 294  
 HACCP verification and review, 297  
 hazard analysis, 298–300*t*  
 menu, 294–5, 295*t*  
 prerequisite programmes, 295–301  
 scope, 293  
 site process, 294*f*  
 terms of reference, 293
- home food safety, 307–9  
 action plan, 309  
 food safety team, 309  
 origin of food safety programme, 308  
 retrospective of previous illnesses, 308–9
- prepared meals, 271–91  
 combining and mixing component meals, 279*f*  
 cooking/cooling, 278*f*  
 decant/batch weigh-in/pre-preparation, 276*f*  
 envisaged consumer use, 272  
 goods receipt, 275*f*  
 HACCP control chart, 290–91*t*  
 HACCP modules, 274*f*  
 HACCP plan, 271  
 HACCP review, 273  
 HACCP team, 271  
 hazard analysis, 282–9  
 hazard analysis procedure, 273  
 intended consumer use, 272  
 materials storage, 275*f*  
 packaging/decant/unwrap, 277*f*  
 prerequisites, 272–3  
 product description, 272  
 scope, 271  
 secondary and tertiary packaging, 280*f*  
 storage and dispatch, 281*f*  
 terms of reference, 271
- shell eggs, 249–68  
 biological hazards, 250  
 bird mortality storage and disposal, 255  
 chemical hazards, 250  
 control measures, 258–65*t*  
 critical control points, 266  
 egg collection, 256  
 feed manufacturing, 254  
 food safety/HACCP team members, 249–50  
 HACCP control chart, 267*t*  
 hazard analysis, 258–65*t*  
 implementation and maintenance, 268  
 induced molting, 255–6  
 manure storage and disposal, 255  
 packing nest-run egg, 256  
 process flow diagrams, 257*f*  
 product, 250  
 pullet and layer flock management, 252–3  
 receiving chicks in pullet buildings, 251–2  
 receiving eggs at processing plant, 257  
 receiving pullet in egg-laying building, 255  
 refrigeration of nest-run eggs, 256–7  
 risk factors, 254  
 terms of reference, 250  
 testing, 253–4  
 vaccination, 253–4
- Center for Science in the Public Interest, 66

- Centers for Disease Control (CDC), 42, 66
- cereal, contamination of, 16*t*
- certificates of analysis (CoAs), 24–5
- challenge testing, 97–100
- chemical agents, 103*t*
- chemical disinfectants, 110–11
- chemical food preservatives, 90–94
  - carbon dioxide, 94
  - essential oils, 94
  - nisin, 94
  - organic acids, 91–3
  - sodium nitrite, 94
  - sulphur compounds, 93–4
- chemical hazards, 78–85. *See also* biological hazards; physical hazards
- allergens, 78–9
- in food packaging materials, 84
- in food processing, 84
- hazard analysis, 200
- heavy metals, 83–4
- in home kitchen, 304
- marine foodborne toxins, 80–81
- mycotoxins, 79–80
- overview, 50
- potential, 84–5
- process control of, 117–19
  - allergen control, 117–18
  - cleaning chemicals, 119
  - maintenance chemicals, 119
  - sanitation chemicals, 119
  - white powder control, 118
- China, 33
  - food exports, 30
  - food trade, 31*t*
  - labour cost in, 33*t*
- chocolate, contamination of, 17*t*
- CIES, 42–3
- ciguatera poisoning, 81
- Claviceps purpurea*, 79
- cleaning, 156
- cleaning chemicals, 119
- cleaning programmes, 162–6. *See also* prerequisite programmes
  - appropriate methods, 163*b*
  - cleaning-in-place programmes, 164*b*
  - drain and janitorial cleaning, 164*b*
  - equipment and chemicals, 165*b*
  - risk evaluation, 163*b*
  - sanitary design, 163*b*
  - schedules and procedures, 163–4*b*
  - training, 166*b*
  - verification, 165–6*b*
- cleaning-in-place, 165*b*
  - operators, 166*b*
- climate change, 35, 59
- closed questions, 231
- Clostridium botulinum*, 33, 49, 73
  - canned food contamination, 7
  - challenge testing, 99
  - growth limits, 72*t*
  - growth temperature, 113*t*
  - oxidation–reduction potential and, 95
  - potential hazards, 304
  - spores, 109
  - symptoms of contamination, 70*t*
  - thermal property values, 109*t*
- Clostridium perfringens*, 49, 70*t*, 72*t*, 73, 109*t*, 113*t*, 304
- Clostridium sporogenes*, 109*t*
- Codex Alimentarius Commission Committee on Food Hygiene (Code), 7–8, 42, 56, 158
- Codex General Principles of Food Hygiene, 228–33
- Codex General Standard for the Labelling of Prepackaged Goods, 170
- Codex logic sequence, 189–215. *See also* HACCP plan
  - corrective actions, 213
  - critical control points, 206–9
  - critical limits, 209
  - documentation and record-keeping, 215
  - HACCP teams, 190–91
  - hazard identification and analysis, 199–206
  - intended use identification, 192–3
  - monitoring system for CCPs, 209–12
  - on-site confirmation of flow diagram, 198–9
  - overview, 187–9
  - process flow diagram, 193–6, 197–8*f*
  - product/process descriptions, 191–2
  - scope, 189, 190*t*
  - terms of reference, 189, 190*t*
  - verification procedures, 213–15
- Commission on Microbiological Criteria for Foods, 7
- consultants, 20
- consulting organisations, 313
- consumer awareness, 170–72
- consumers, 28
- contamination, 114–17
  - from foreign materials, 119
  - major food incidents, 16–17*t*
  - prevention of, 106, 114–17
    - allergenic ingredient control, 115
    - aqueous ingredient control, 116
    - high-risk ingredient control, 115
    - moisture control, 117
    - sanitary design and sanitation, 116–17
- continuous improvement programmes, 130, 143
- control measures, 49, 199, 205–6, 304–6
- Cooperative Extension System, 270

- corporate offices, 53
- corrective actions, 150–52, 213
- costs, 12–13
  - of failure, 13
  - of implementation, 13
  - misconceptions, 15
  - of prevention, 12–13
- counterfeiting, 41
- Coxiella burnettii*, 107
- Creutzfeldt–Jakob disease (CJD), 77
- crisis management, 27
- critical control points (CCPs), 206–9. *See also* Codex Alimentarius Commission Committee on Food Hygiene (Code); Codex logic sequence
  - critical limits, 209
  - decision record, 209*t*
  - decision tree, 207*f*
  - farm-to-table HACCP and, 10
  - hazard analysis/determination of, 22, 206–9
  - in home kitchen, 306–7
  - identification of, 266
  - management systems, 221
  - monitoring system, 209–12
- critical limits, 22–3
- Cronobacter sakazakii*, 69, 75
- cross-contamination, 53
- Cryptosporidium*, 49
- Cryptosporidium parvum*, 68*t*, 78*t*
- customer complaint records, 227
- customer offices, 53
- cyanuric acid, 40, 84
- Cyclospora*, 49
- Cyclospora cayetanensis*, 68*t*, 78*t*
  
- defective units, 4–5, 5*t*
- deli meats, contamination of, 17*t*
- deoxynivalenol, 41*t*, 79, 103*t*
- Department of Health and Human Services, 42
- detection techniques, 121–2
- diarrhoeic shellfish poisoning, 80
- diethylene glycol, 39
- dioxins, 82
- Diphyllobothrium latum*, 78*t*
- dipstick test, 118
- documentation, 142
  - of HACCP system, 215
  - misconceptions, 15
  - operational control, 161
- domoic acid poisoning, 81
- drains, 164*b*
- dried cere mixes, 4
- dried ingredients, 4
- dried milk powder, contamination of, 18*t*
  
- dry cleaning, 165*b*
- dry-heat processes, 110
- Dutch HACCP Code, 233
  
- education, 54–5, 55*f*
- eggs, *Salmonella* contamination, 4
- electric insect killers, 38, 168*b*
- emerging economies, 33
- employees, commitment of, 24
- end product testing, 60
- enforcement, 57–8
- Entamoeba histolytica*, 78*t*
- enterotoxins, 69
- environmental hygiene, 156
- environmental surveillance programmes, 166*b*
- enzyme-linked immunosorbent assay (ELISA), 118
- epidemiology, 66–9
- equilibrium relative humidity, 88
- equipment, 158
- ergot, 103*t*
- ergotism, 79
- Escherichia coli*, 9, 25, 68*t*, 107*t*
  - Shiga toxin-producing, 67*t*
- Escherichia coli* O157:H7, 49, 56, 61, 68*t*, 70–72*t*, 74, 103, 107*t*, 113*t*, 304
- essential management practices, 129
- essential oils, 94
- ethanol, 36
- Europe
  - food trade, 31*t*
  - global food sourcing, 31*t*
- European Union
  - food trade, 31*t*
  - labour cost in, 33*t*
- event catering (case study), 293–301
  - HACCP control chart, 301*t*
  - HACCP study, 297
  - HACCP team, 294
  - HACCP verification and review, 297
  - hazard analysis, 298–300*t*
  - menu, 294–5, 295*t*
  - prerequisite programmes, 295–301
  - scope, 293
  - site process, 294*f*
  - terms of reference, 293
- exclusion techniques, 119–20
- experimental design and analysis, 97–102
  - accelerated shelf life testing, 100–101
  - challenge testing, 97–100
  - mathematical modelling, 101
  - predictive microbiology, 101
  - theory vs. reality, 101–2
- external cost of failure, 13

- facilities, 158
- failure modes and effects analysis, 5
- Farina (baby food), 5
- farm-to-table HACCP, 20
- filtration, 110
- finfish poisoning, 81
- fish, 31*t*
- fish allergen, 18*t*
- Food and Agriculture Organization (FAO), 8, 56
- Food and Drug Administration (FDA), 7, 39
- Food Business Forum, 42
- food commodity trade, 31*t*
- food defence, 126–7
- food incidents, 16–17*t*
  - food categories and, 67*t*
- food poisoning, 69
- food preservatives, 90–94
  - carbon dioxide, 94
  - essential oils, 94
  - nisin, 94
  - organic acids, 91–3
  - sodium nitrite, 94
  - sulphur compounds, 93–4
- Food Protection Organization (FPO), 56
- food safety, 126
- food safety events, 21
- food safety hazards, 65–86
  - biological hazards, 66–78
    - bacterial pathogens, 73–5
    - epidemiological data, 66–9
    - foodborne illnesses, 69–73
    - in home kitchen, 304
    - morbidity statistics, 66–9
    - parasitic worms, 78
    - prions, 76–7
    - process control of, 106–7
    - protozoan parasites, 77–8
    - viral pathogens, 75–6
  - chemical hazards, 78–85
    - allergens, 78–9
    - in food packaging materials, 84
    - in food processing, 84
    - hazard analysis, 200
    - heavy metals, 83–4
    - in home kitchen, 304
    - marine foodborne toxins, 80–81
    - mycotoxins, 79–80
    - overview, 50
    - potential, 84–5
    - process control of, 117–19
  - definition of, 65
  - exceptions, 65–6
  - physical hazards, 85–6
    - control of, 119–22
    - hazard analysis, 200
    - in home kitchen, 304
    - injuries associated with, 85–6
    - sources foreign material, 85
- food safety issues, 49–50
  - allergens, 50
  - antibiotic-resistant pathogens, 50
  - changes in pathogen distribution, 49
  - chemical hazards, 50
  - control measures, 49
  - emerging pathogens, 49
  - physical hazards, 50
- food safety management, 51–9
  - additions to prerequisite programmes, 52–3
  - HACCP preliminary steps and principles, 51–2
  - history of, 3–5
  - mistakes in, 22–4
- food safety objectives (FSOs), 59–60
- food safety professionals, availability of, 55
- food safety programme, 125–32
  - continuous improvement of, 131
  - corrective actions, 150–52
  - definition of, 126
  - elements of, 134*f*
  - essential management practices, 129, 135–43
    - assignment of roles and responsibilities, 135–6
    - continuous improvement programmes, 143
    - documentation, 142
    - management commitment, 135–6
    - resource management, 139–42
    - supplier-customer partnership, 142
    - training and education, 136–9
  - fundamental elements of, 126*f*, 127–8
    - HACCP, 128
    - prerequisite programmes, 128
    - safe product/process design, 127–8
  - in global food supply chain, 130–31
  - overview, 125
  - preparation activities, 143–50
    - gap assessment, 144–50
    - HACCP programme restructuring, 144
    - project plan, 143–4
- food safety programme maintenance, 224–34
  - audit, 228–33
    - auditor, 230–31
    - certification schemes, 231–2
    - checklist, 231–2
    - definitions, 229–30
    - external, 232–3
    - skills, 230–31
  - elements of, 224–5, 225*f*
  - HACCP system elements, 226–8
    - maintenance activities, 227–8
    - verification activities, 226–7

- food safety programme maintenance (*Cont.*)
  - incident management, 233
  - prerequisite programme elements, 226
  - responsibility for, 225–6
- food safety programme, supporting elements, 129–30
- food security, 126–7
- food service (case study), 293–301
  - HACCP control chart, 301*t*
  - HACCP study, 297
  - HACCP team, 294
  - HACCP verification and review, 297
  - hazard analysis, 298–300*t*
  - menu, 294–5, 295*t*
  - prerequisite programmes, 295–301
  - scope, 293
  - site process, 294*f*
  - terms of reference, 293
- food service establishments, 27
- Foodborne Diseases Active Surveillance Network (FoodNet), 42, 66
- foodborne illnesses, 4
  - characteristics of, 69–73
    - emerging pathogens, 72–3
    - incubation period, 70
    - infectious dose, 69–70
    - principal types, 71
    - sources of pathogens, 71
    - symptoms, 70
    - toxic dose, 69–70
  - epidemiology and morbidity statistics, 66–9
  - predisposition to illness, 69
  - statistics, 66
  - types of illness, 69
  - under-reporting of, 70–71
- foot and mouth disease (FMD), 76
- foreign material, control of, 121
- fossil fuels, 35
- fresh produce, outbreaks of foodborne illnesses, 68*t*
- fresh water supply, 35
- frozen meals, contamination of, 18*t*
- frozen meat, first cargo of, 32
- fruit juice, imports, 30
- fruits, 31*t*
  - imports, 30
- fugu poisoning, 81
- fumonisin, 41*t*, 79–80, 103*t*
- fungicides, 82
- Fusarium*, 79
- Gambier discus toxicus*, 81
- gap assessment, 144–50
  - HACCP programme, 149
  - human resource, 150
  - management practices, 150
  - world-class food safety programme, 144–50
    - prerequisite programme, 144–9
    - safe product design, 144
- genetically modified foods, 81
- GFSI Guidance Document, 42
- Giardia lamblia*, 68*t*, 78*t*
- giardiasis, 67*t*
- glass contamination, control of, 119
- global food safety assurance, 53–9
  - combined approach, 58–9
  - enforcement, 57–8
  - human factor in, 53–5
  - oversight and harmonisation, 53–5
- global food safety audit standards, 42–3
- Global Food Safety Initiative (GFSI), 42–3, 53–5, 149, 231
- global food safety resources, 311–13
  - academic institutions, 313
  - audit organisations, 313
  - consulting organisations, 313
  - governmental organisations, 311–12
  - intergovernmental organisations, 311
  - laboratories, 313
  - non-governmental organisations, 312
  - professional associations, 312–13
  - public–private partnerships (PPPs), 312
  - trade associations, 312
- Global Initiative for Food Systems Leadership, 43
- global sourcing, 30
- global supply chain, 33
  - economic factors, 32–3
    - emerging economies, 33
    - labour, 32, 33*t*
    - land, 32
  - environmental factors, 33–6
    - alternative energy sources, 35–6
    - arable land, 34
    - climate change, 34
    - fossil fuels, 35
    - pathogen range, 33–4
    - water availability, 35
  - history, 30, 32
  - import/export statistics, 31*t*
  - social factors, 36–7
    - human overpopulation, 36–7
    - immunocompromised people, 37
    - living standards, 37
    - year-round sourcing, 37
  - world-class food safety programme, 130–31
- global trade
  - food safety issues in, 37–41
    - audit requirements, 41
    - regulations and requirements, 39–41
- Good Manufacturing Practices (GMP), 39

- government, 26
- government communications systems, 41–2
- government offices, 53
- governmental organisations, 311–12
- grains, mycotoxin limits, 41*t*
- Great Depression, 3
- green onion, 68*t*
- groundwater, 35
- Gymnodinium breve*, 81
  
- H1N1 influenza, 33
- H5N1 influenza, 33
- HACCP
  - applying through food supply chain, 24–6
  - barriers to effective use, 20–21
  - benefits of, 12–14
  - costs of, 15
  - future of, 10–11
  - implementation, 216–23
    - action planning, 217–20
    - CCP management systems, 221
    - handover to operations staff, 222
    - mistakes in, 22–4
    - project Gantt chart, 219*f*
    - required activities, 221–2
    - stages, 133
    - steps, 218*f*
    - training, 220
    - updates and changes to existing systems, 223
    - validated HACCP plan, 217
    - verification of, 221–2
  - misconceptions, 14–20
  - modules. *See* HACCP modules
  - origin and evolution of, 5–10
  - plan. *See* HACCP plan
  - preliminary steps and principles, 51–2
  - prerequisite programmes, 10
  - principles, 8, 128*t*, 186*t*
  - reasons for failure, 21–4
    - implementation mistakes, 22–4
    - lessons from food safety events, 21
    - mismanagement of food safety programmes, 22–4
  - roles and responsibilities, 26–8
    - academia, 27–8
    - advocacy and pressure groups, 28
    - consumers, 28
    - food service establishments, 27
    - government, 26–7
    - industry, 26–7
    - media, 28
    - retailers, 27
    - trade and professional associations, 27–8
  - rules, 8–9
  - significant events, 6*t*
  - teams, 190–92
- HACCP modules, 274*f*
  - combining and mixing component meals, 279*f*
  - cooking/cooling, 278*f*
  - decant/batch weigh-in/pre-preparation, 276*f*
  - goods receipt, 275*f*
  - materials storage, 275*f*
  - packaging/decant/unwrap, 277*f*
  - secondary and tertiary packaging, 280*f*
  - storage and dispatch, 281*f*
- HACCP plan, 15, 185–215
  - application process, 187, 188*t*
  - Codex logic sequence, 189–215
    - corrective actions, 213
    - critical control points, 206–9
    - critical limits, 209
    - documentation and record-keeping, 215
    - HACCP teams, 190–91
    - hazard identification and analysis, 199–206
    - intended use identification, 192–3
    - monitoring system for CCPs, 209–12
    - on-site confirmation of flow diagram, 198–9
    - overview, 187–9
    - process flow diagram, 193–6, 197–8*f*
    - product/process descriptions, 191–2
    - scope, 189, 190*t*
    - terms of reference, 189, 190*t*
    - verification procedures, 213–15
  - core plan, 186
  - documenting study and plan development, 187
  - support documentation, 187
  - validated, 217
- HACCP records, 227
- handling, 156
- hazard, 199
- hazard analysis, 60–61, 199
  - chart headings, 201*t*
  - questionnaires, 204–5*t*
- Hazard Analysis and Critical Control Points. *See* HACCP
- hazards, 65–86
  - biological, 66–78
    - bacterial pathogens, 73–5
    - epidemiological data, 66–9
    - foodborne illnesses, 69–73
    - in home kitchen, 304
    - morbidity statistics, 66–9
    - parasitic worms, 78
    - prions, 76–7
    - process control of, 106–7
    - protozoan parasites, 77–8
    - viral pathogens, 75–6
  - chemical, 78–85

- hazards (*Cont.*)
- allergens, 78–9
  - in food packaging materials, 84
  - in food processing, 84
  - hazard analysis, 200
  - heavy metals, 83–4
  - in home kitchen, 304
  - marine foodborne toxins, 80–81
  - mycotoxins, 79–80
  - overview, 50
  - potential, 84–5
  - process control of, 117–19
  - in home kitchen, 304
  - physical, 85–6
    - control of, 119–22
    - hazard analysis, 200
    - in home kitchen, 304
    - injuries associated with, 85–6
    - sources foreign material, 85
  - risk evaluation, 202
  - significance assessment, 202–5
  - significance assessment table, 203*t*
- hazelnut yogurt, contamination of, 16*t*
- health status, 169
- heating, 306
- heavy metals, 83–4
  - arsenic, 83
  - cadmium, 83
  - as food safety hazard, 39
  - lead, 83
  - mercury, 83
  - uranium, 83–4
- Henderson–Hasselbalch equation, 91
- hepatitis A, 67*t*
- hepatitis A virus, 68*t*, 70*t*, 76*t*
- hexachlorobenzene, 82
- high hydrostatic pressure (HHP), 111–12
- high-risk ingredients, 102–4, 115
- histamine poisoning, 81
- home food safety, 303–9
  - case study, 307–9
    - action plan, 309
    - food safety team, 309
    - origin of food safety programme, 308
    - retrospective of previous illnesses, 308–9
  - control measures, 304–6
    - heating, 306
    - personal hygiene, 306
    - refrigeration, 305
    - sanitation, 306
  - critical control points, 306–7
  - education, 307
  - potential hazards, 304
- hot-holding, 113–14
- human resource, gap assessment, 150
- human resources, 20
- hygienic production, 156
- hypothetical questions, 231
- ice cream, contamination of, 16*t*
- ice cream mix, pasteurisation of, 107*t*
- iceboxes, 3
- illnesses, 170
- illnesses, foodborne, 4
  - characteristics of, 69–73
    - emerging pathogens, 72–3
    - incubation period, 70
    - infectious dose, 69–70
    - principal types, 71
    - sources of pathogens, 71
    - symptoms, 70
    - toxic dose, 69–70
  - epidemiology and morbidity statistics, 66–9
  - predisposition to illness, 69
  - statistics, 66
  - types of illness, 69
  - under-reporting of, 70–71
- immunocompromised people, 37, 59, 69
- incident management, 233
- incubation period, 70
- India, 33
  - food trade, 31*t*
- Indonesia, food trade, 31*t*
- Industry Council for Development, 55
- infections, 69
- infectious dose, 69–70
- influenza viruses, 76
- information searching, 228
- ingredients, 101–2
  - allergenic, 115
  - aqueous, 116
  - high-risk, 102–4, 115
- injuries, 170
- insect control, 168*b*
- intergovernmental organisations, 311
- internal cost of failure, 13
- internal traps, 168*b*
- International Food Standard, 42
- International Register of Certificated Auditors (IRCA), 43
- intoxications, 69
- intrinsic control factors, 87–97
  - chemical food preservatives, 90–94
  - oxidation–reduction potential, 94–5
  - pH, 90
  - preservative factors, 95–6
  - water activity, 88–90
- ionising radiation, 111

- irrigation water, 35
- ISO 22000:2005, 173–5, 232
- jalapeno peppers, conditions associated with, 17*t*
- janitorial cleaning, 164*b*
- Japan
  - food trade, 31*t*
  - labour cost in, 33*t*
- Joint FAO/WHO Food Standards Programme, 42
- Kenya, food trade, 31*t*
- knowledge resources, 55
- labelling, 170–72
  - requirements, 160*t*
  - transportation and, 160
- laboratories, 313
- laboratory detection equipment, 50
- labour, 32, 33*t*
- land, 32
  - arable, 34
  - use for biofuel production, 59
- Lapland UK food service (case study), 293–301
  - HACCP control chart, 301*t*
  - HACCP study, 297
  - HACCP team, 294
  - HACCP verification and review, 297
  - hazard analysis, 298–300*t*
  - menu, 294–5, 295*t*
  - prerequisite programmes, 295–301
  - scope, 293
  - site process, 294*f*
  - terms of reference, 293
- Latin America, food retail sales in, 33
- lead, 83
- leadership, 54–5
- leading questions, 231
- learning pyramid, 138*t*
- lettuce, 68*t*
- liquid eggs, pasteurisation of, 107*t*
- Listeria monocytogenes*, 49, 74–5
  - in cheese and cheese products, 38
  - control of, 9
  - eliminating hazards of, 46
  - growth limits, 72*t*
  - growth temperature, 113*t*
  - hazard analysis, 304
  - in high-risk food ingredients, 103, 103*t*
  - identification of, 22
  - major food incidents, 17*t*
  - natural habitat, 71*t*
  - pasteurisation and, 108
  - risk assessment, 61
  - symptoms of contamination, 70*t*
  - thermal resistance, 107*t*
- listeriosis, 67*t*, 69
- living standards, 37
- local language materials, 20
- lot identification, 170
- low-income countries, 33
- mad cow disease, 77
- maintenance, 156, 161–9, 227–8
- maintenance chemicals, 119
- maize, 31*t*
  - ethanol production from, 36
  - mycotoxin limits, 41*t*
- management, commitment of, 23
- marine foodborne toxins, 80–81
- master sanitation schedule (MSS), 163–4
- material test records, 227
- mathematical modelling, 101
- mechanical refrigeration, 3–4
- mechanical traps, 168*b*
- media, 28
- megareg, 8
- melamine, 18*t*, 39–40, 84
- melon, 68*t*
- mercury, 83
- metal contamination, control of, 120–21
- metal detection, 291*t*
- methane, 36
- Mexico
  - food trade, 31*t*
  - labour cost in, 33*t*
- microbial growth
  - effects of various factors on, 96–7*f*
  - prevention of, 105, 112–14
    - freezing, 113
    - hot-holding, 113–14
    - modified atmosphere, 114
    - refrigeration, 112–13
    - vacuum packaging, 114
  - requirements, 148*f*
- microbiological hazards. *See* biological hazards
- microorganisms
  - destruction of, 105
    - non-thermal processes, 110–12
    - thermal processes, 106–10
- milk
  - pasteurisation of, 107*t*
  - Salmonella* contamination, 4
- milk products, contamination of, 16*t*
- mixed fruit, 68*t*
- mixed salad, 68*t*
- mixed vegetables, 68*t*
- modified atmosphere, 114

- moisture control, 117  
molting, 255–6  
morbidity, 66–9  
*Mycobacterium avium* subsp. *paratuberculosis*, 75  
*Mycobacterium tuberculosis*, 107  
mycotoxins, 40, 79, 103*t*
- National Advisory Committee on Microbiological  
Criteria for Foods, 7  
National Aeronautics and Space Administration  
(NASA), 5  
National Antimicrobial Resistance Monitoring  
System, 42  
National Conference on Food Protection, 6  
National Research Council, 7  
nest-run eggs  
packing, 256  
refrigeration of, 256–7  
newly industrialized economies (NIEs), labour cost  
in, 33*t*  
nisin, 94  
non spore-forming bacterial pathogens, 73–5  
non-governmental organisations, 312  
non-thermal processes, 110–12  
chemical disinfectants, 110–11  
filtration, 110  
high hydrostatic pressure, 111–12  
ionising radiation, 111  
pulsed electric fields, 111–12  
ultraviolet light, 111  
norovirus, 68*t*, 76*t*  
North American, food trade, 31*t*  
nuts, mycotoxin limits, 41*t*
- ocean shipping, relative efficiency of, 37*t*  
ochratoxin, 41*t*, 79, 103*t*  
oil reserves, 35  
One World One Health project, 43  
open questions, 231  
operational prerequisites, 173–5  
opportunistic pathogens, 69  
orange juice, 68*t*  
organic acids, 91–3  
out-of-place cleaning, 166*b*  
overpopulation, 36–7  
oxidation–reduction potential, 94–5
- packaging design, 161  
Panisello pyramids, 152*f*  
para red, 39  
parabens, 91  
paralytic shellfish poisoning, 80  
parasitic infections, 66*t*  
parasitic worms, 78  
PAS 220:2008, 232
- pasteurisation, 106–8  
Pasteurized Milk Ordinance (PMO), 7, 106  
Pathogen Modelling Program, 101  
pathogens, 33–4  
antibiotic-resistant, 50  
changes in distribution of, 49  
emerging, 49  
patulin, 79  
peak oil production, 35  
peanut butter, contamination of, 18*t*, 53  
*Penicillium*, 79  
*Penicillium* spp., 93  
periodic review, 228  
perishable foods, 3  
persistent organic pollutants (POPs), 82  
personal hygiene, 156, 169–70, 295, 306  
personnel practices, 120  
pest control, 120, 166–8  
bird control, 168*b*  
chemicals, 167*b*  
insect control, 168*b*  
objectives in, 167  
procedures, 167*b*  
rodent control, 168*b*  
pesticides, 39, 82  
pH, 90  
pheromone traps, 168*b*  
physical hazards, 85–6. *See also* biological hazards;  
chemical hazards  
control of, 119–22  
hazard analysis, 200  
in home kitchen, 304  
injuries associated with, 85–6  
overview, 50  
process control of, 119–22  
detection techniques, 121–2  
exclusion techniques, 119–20  
removal techniques, 120–21  
physical hazards, sources foreign material, 85  
Pillsbury Company, 5–7, 46  
plan-do-check-act (PDCA) cycle, 133, 134*f*  
plastic contamination, control of, 119  
policymaking, 59–61  
end product testing, 60  
food safety objectives, 59–60  
hazard analysis vs. risk assessment, 60–61  
polychlorinated biphenyls, 82  
population, 36–7, 59  
potato chips, contamination of, 16*t*  
poultry, 25, 31*t*  
predictive microbiology, 101  
prepared meals (case study), 271–91  
envisaged consumer use, 272  
HACCP control chart, 290–91*t*

- HACCP modules, 274*f*
  - combining and mixing component meals, 279*f*
  - cooking/cooling, 278*f*
  - decant/batch weigh-in/pre-preparation, 276*f*
  - goods receipt, 275*f*
  - materials storage, 275*f*
  - packaging/decant/unwrap, 277*f*
  - secondary and tertiary packaging, 280*f*
  - storage and dispatch, 281*f*
- HACCP plan, 271
- HACCP review, 273
- HACCP team, 271
- hazard analysis, 282–9
- hazard analysis procedure, 273
- intended consumer use, 272
- prerequisites, 272–3
- product description, 272
- scope, 271
- terms of reference, 271
- prerequisite programmes, 128, 154–75
  - consumer awareness, 170–72
  - decision tree, 174*f*
  - definition, 155
  - establishment, 157–70
    - design and layout, 157–8
    - equipment, 158
    - facilities, 158
    - maintenance, 161–9
    - personal hygiene, 169–70
    - sanitation, 161–9
  - in food service, 295–301
  - gap assessment, 144–9
  - HACCP and, 22, 24–5, 52–3
  - HACCP plan, 15
  - necessity for, 10
  - operational control, 158–61
    - of food hazards, 158–60
    - prerequisite elements, 159*f*
  - operational prerequisites, 173–5
  - overview, 154
  - primary production, 156–7
  - product information, 170–72
  - risk evaluation, 148
  - training, 172–3
  - transportation, 170
  - validation, 175
  - verification, 175
- preservative factors, 95–6
- preservatives, 90–94
  - carbon dioxide, 94
  - essential oils, 94
  - nisin, 94
  - organic acids, 91–3
  - sodium nitrite, 94
  - sulphur compounds, 93–4
- pressure groups, 28
- primary production prerequisite programmes, 156–7
- prions, 76–7
- prioritisation quadrant diagram, 151*f*
- process control, 106–22
  - of chemical hazards, 117–19
    - allergen control, 117–18
    - cleaning chemicals, 119
    - maintenance chemicals, 119
    - sanitation chemicals, 119
    - white powder control, 118
  - of microbiological hazards, 106–17
    - destruction of microorganisms, 106–12
    - prevention of contamination, 114–17
    - prevention of microbial growth, 112–14
  - of physical hazards, 119–22
    - detection techniques, 121–2
    - exclusion techniques, 119–20
    - removal techniques, 120–21
- process design and control, 105–22
- process development, 227–8
- process flow diagrams, 22
- process operation module, 145*f*
- processed food trade, 32*f*
- product design, 159
- product development, 227–8
- product information, 170–72
- product safety, 87–104
  - experimental design and analysis, 97–102
    - accelerated shelf life testing, 100–101
    - challenge testing, 97–100
    - mathematical modelling, 101
    - predictive microbiology, 101
    - theory vs. reality, 101–2
  - ingredients, 102–4
  - intrinsic control factors, 22, 87–97
    - chemical food preservatives, 90–94
    - oxidation–reduction potential, 94–5
    - pH, 90
    - preservative factors, 95–6
    - water activity, 88–90
- product safety assessment (PSA), 176–84
  - example of, 179–84
  - previous approaches in, 178–9
  - process, 178
  - process flow diagram, 182*f*
  - product development team, 176–7
  - research staff, 176
  - team, 177
  - timing of, 177
  - training, 179
- product test records, 227

- product testing, 39
- product/process description, 191–2
- professional associations, 27–8, 312–13
- propionic acid, 91
- Proteus* spp., 81
- protozoan parasites, 77–8
- Pseudomonas fluorescens*, 107*t*
- Pseudomonas* spp., 101
- Pseudonitzschia*, 81
- public health, protection of, 12
- publications, misleading, 20–21
- public–private partnerships (PPPs), 43, 312
- puffer fish poisoning, 81
- pullet and layer flock management, 252–3
  - farm sanitation, 252–3
  - insects, 253
  - pest control, 252–3
  - rodents, 253
  - traffic control, 252
  - water quality, 252
- pulsed electric fields, 111–12
- PulseNet, 42
  
- quality control, 13
- quality management systems, 129
  
- railroad, relative efficiency of, 37*t*
- Raleigh, Walter, 30
- raw meat, 25
- real-time monitoring, 13–14
- recall procedures, 161
- record-keeping, 215
- records, 161
- red meat, 31*t*
- refrigerated transportation, 3
- refrigeration, 112–13, 305
  - mechanical, 3
- refusals, 38*t*
- Register of Professional Food Auditors and Mentors, 43
- regulatory obligations, 14
- removal techniques, 120–21
- renewable energy, 35–6
- resource management, 139–42
- resources, 311–13
  - academic institutions, 313
  - audit organisations, 313
  - consulting organisations, 313
  - governmental organisations, 311–12
  - intergovernmental organisations, 311
  - laboratories, 313
  - non-governmental organisations, 312
  - professional associations, 312–13
  - public-private partnerships (PPPs), 312
  - trade associations, 312
  - use of, 14
- retailers, 27
- review, 228
- rice, 31*t*
- risk assessment, 60–61
- robotics, 50
- rodent control, 168*b*
- roles and responsibilities, 26–8
  - academia, 27–8
  - advocacy and pressure groups, 28
  - consumers, 28
  - food service establishments, 27
  - government, 26–7
  - industry, 26–7
  - media, 28
  - retailers, 27
  - trade and professional associations, 27–8
- rotovirus, 76*t*
- roundworms, 78*t*
- Russia, food trade, 31*t*
  
- safe product/process design, 127–8
- Safe Supply of Affordable Food Everywhere Inc., 43
- Salmonella*, 33, 49, 74
  - contamination, 4, 8–9
  - growth limits, 72*t*
  - growth temperature, 113*t*
  - hazard analysis, 22
  - in high-risk food ingredients, 102, 103*t*
  - major food incidents, 16*t*
  - natural habitat, 71*t*
  - number of outbreaks, 68*t*
  - performance standards, 9*t*
  - potential hazards, 304
  - symptoms of contamination, 70*t*
  - thermal resistance, 107*t*
- Salmonella agona*, 16*t*
- Salmonella enteritidis*, 16*t*, 251–2
- Salmonella montevideo*, 17*t*
- Salmonella senftenberg*, 107*t*
- Salmonella St. Paul*, 17–18*t*
- Salmonella typhimurium*, 18*t*
- salmonellosis, 67*t*, 69
- sanitary design, 116–17, 163*b*
- sanitation, 116–17, 146–7, 161–9
  - chemicals, 165*b*
  - efficacy of, 146–7
  - in home kitchen, 306
  - manager, 166*b*
  - risk evaluation, 146
  - schedules and procedures, 163–4*b*
  - tools and equipment, 165*b*
- sanitation chemicals, 119

- scombroid poisoning, 81
- scrapie, 77
- seafood, 31*t*
- seed sprouts, 68*t*
- shell eggs (food safety case study), 249–68
  - control measures, 258–65*t*
  - critical control points, 266
  - food safety/HACCP team members, 249–50
  - HACCP control chart, 267*t*
  - hazard analysis, 258–65*t*
  - implementation and maintenance, 268
  - process flow diagrams, 257*f*
  - product/process description, 250–57
    - biological hazards, 250
    - bird mortality storage and disposal, 255
    - chemical hazards, 250
    - egg collection, 256
    - feed manufacturing, 254
    - induced molting, 255–6
    - manure storage and disposal, 255
    - packing nest-run egg, 256
    - product, 250
    - pullet and layer flock management, 252–3
    - receiving chicks in pullet buildings, 251–2
    - receiving eggs at processing plant, 257
    - receiving pullet in egg-laying building, 255
    - refrigeration of nest-run eggs, 256–7
    - risk factors, 254
    - testing, 253–4
    - vaccination, 253–4
  - terms of reference, 250
- shellfish poisoning, 80
- Shiga toxin-producing *E. coli*, 67*t*
- Shigella*, 68*t*
- Shigella* spp., 70–72*t*, 75
- shigellosis, 67*t*
- sodium nitrite, 94
- sorbic acid, 91–2
- South Africa, food trade, 31*t*
- South America, food trade, 31*t*
- South Korea, food trade, 31*t*
- soya beans, 31*t*
- Space Food Sticks, 5–6, 6*f*
- spices, contamination of, 17*t*
- spoilage, 66
- spore-forming bacterial pathogens, 73
- spray-dried egg albumen, pasteurisation of, 107*t*
- staphylococcal poisoning, 69
- Staphylococcus aureus*, 33, 75
  - growth limits, 72*t*
  - growth temperature, 113*t*
  - in high-risk food ingredients, 102–3, 103*t*
  - outbreaks of foodborne illnesses, 68*t*
  - potential hazards, 304
    - symptoms of contamination, 70*t*
    - thermal resistance, 107*t*
- Staphylococcus aureus* toxin, 16*t*
- sterilisation, 108–10
  - canning processes, 109
  - dry-heat processes, 110
  - UHT processes, 110
- storage, 156
- strategies, 41–3
  - auditor competency, 43
  - global food safety audit standards, 42–3
  - government communications systems, 41–2
  - public–private partnerships, 43
- Sudan red, 17*t*, 39
- sudden acute respiratory syndrome (SARS), 76
- sulphur compounds, 93–4
- supplier audits and approval, 44–5
- supplier quality assurance (SQA), 147–9
- suppliers, approved lists, 45
- supply chain model, 24*f*, 130*f*
- supply quality assurance (SQA), 24
- sustainability programmes, 130
- tactical level responses, 43–6. *See also* food safety management
  - approved supplier lists, 45
  - business continuity planning, 45–6
  - shared audits and, 45
  - supplier audits and approval, 44–5
  - technology sharing, 46
- Taenia saginata*, 78*t*
- Taenia solium*, 78*t*
- tapeworms, 78*t*
- technology advancements, 50–51
- technology sharing, 46
- temperature control, 295
- temple of food and safety, 26*f*
- Tesco, 42
- tetrodotoxin, 81
- thermal processes, 106–10
  - pasteurisation, 106–8
  - sterilisation, 108–10
- third-party consultants, 20
- tomato, 68*t*
- Total Productive Maintenance (TMP), 130
- Total Quality Management (TMQ), 129
- toxic dose, 69–70
- Toxoplasma gondii*, 78*t*
- trade associations, 27–8, 312
- training
  - additions to prerequisite programmes, 52–3
  - breakthrough learning, 138–9
  - cleaning programmes, 166*b*
  - desired outcomes, 136–7

- training (*Cont.*)
- food safety training, 137
  - HACCP implementation, 220
  - HACCP maintenance, 228
  - learning pyramid, 137–8
  - overview sessions, 137
  - in prerequisite programmes, 172–3
  - product safety assessment, 179
  - of workforce, 54–5, 55 *f*
- transmissible spongiform encephalopathy (TSE), 77
- transportation, 170
- labelling and, 160
  - modes, efficiency of, 37*t*
  - in primary production, 156
- transposition, 295
- Trichinella spiralis*, 78*t*
- trichinellosis, 67*t*
- trucking, relative efficiency of, 37*t*
- TruQ, 45
- ultra-high temperature (UHT), 109
- ultra-high temperature (UHT) processes, 110
- ultraviolet light, 111
- United Kingdom, global food sourcing, 31*t*
- United States
- energy consumption in, 36
  - food trade, 31*t*
  - labour cost in, 33*t*
  - processed food trade, 32*t*
- uranium, 83–4
- US Army Laboratories, 5
- vacuum packaging, 114
- validation, 20–21, 213–15
- variant Creutzfeldt–Jakob disease (vCJD), 77
- vegetable juice, imports, 30
- vegetable oils, 31*t*
- vegetables, 31*t*
- Venezuela, food trade, 31*t*
- verification, 23
- activities, 226–7
  - difficulties, 21
  - procedures, 213–15
  - review of records, 227
  - system audit, 226–7
- Vibrio parahaemolyticus*, 72*t*, 113*t*
- Vibrio* spp., 68, 70–71*t*, 75
- Vibrio vulnificus*, 49
- viral pathogens, 75–6
- vomitoxin, 79
- Walmart, 42
- waste management, 168–9
- water activity, 88–90
- water supply, 35
- wet cleaning, 165*b*
- wheat
- imports and exports, 31*t*
  - mycotoxin limits, 41*t*
- white powder control, 118
- wood contamination, control of, 120
- World Health Organization, 56
- World Organization of Animal Health, 56
- World Trade Organization, 8, 42
- world-class food safety programme, 125–32
- continuous improvement of, 131
  - corrective actions, 150–52
  - definition of, 126
  - elements of, 134 *f*
  - essential management practices, 129, 135–43
    - assignment of roles and responsibilities, 135–6
    - continuous improvement programmes, 143
    - documentation, 142
    - management commitment, 135–6
    - resource management, 139–42
    - supplier-customer partnership, 142
    - training and education, 136–9
  - fundamental elements of, 126 *f*, 127–8
    - HACCP, 128
    - prerequisite programmes, 128
    - safe product/process design, 127–8
  - in global food supply chain, 130–31
  - overview, 125
  - preparation activities, 143–50
    - gap assessment, 144–50
    - HACCP programme restructuring, 144
    - project plan, 143–4
  - supporting elements, 129–30
- Yersinia enterocolitica*, 68*t*, 70–72*t*, 75, 113*t*
- yogurt, contamination of, 16*t*
- zearalenone, 41*t*, 79, 103*t*
- zero risk, 19–20