

Index

- A**
 Abraham Schinken, 46
 Acidification, combinations of
 nonthermal processes and
 high hydrostatic pressure, 411
 irradiation, 411
 pulsed electric fields, 392–393,
 393 *f*, 411–412
 ultrasound, 412
 Acoustic cavitation, 139–140
 enhancing cavitation activity,
 140
 stable (static) cavitation,
 139–140
 transient cavitations, 139
 Acoustic streaming, 109
Aeromonas hydrophila, 379
 “Afterglow” technologies, 276,
 277 *f*, 278
 Allyl isothiocyanate (AITC), 463,
 465–467, 465*t*, 468 *f*
 Alternative food-processing
 technologies, regulations
 and, 562–570
 food additive/food contact
 concerns, 565–566
 labeling issues of concern,
 566–567
 organism of concern, 563–565
 overview, 562–563, 570
 process validation concerns,
 567–570
 responsibilities, 570
 AmeriQual, 45
 Anisotropic radio frequency electric
 field strength, 217, 217 *f*
 Anthocyanin extraction, pulsed elec-
 tric fields and, 197, 197 *f*
 Antimicrobial agents, combinations
 of nonthermal processes
 and
 high hydrostatic pressure, 398,
 412–413
 hydrodynamic pressure
 processing, 103–104
 irradiation, 389, 416
 pulsed electric fields, 393–394,
 416–417
 ultrasound, 385–386, 417–418
 Antimicrobial packaging, 462–470
 antimicrobial compounds and
 methods of incorporation
 in packaging materials,
 464–466, 465*t*, 466 *f*
 direct contact and transfer by
 migration systems,
 462–463, 463*t*
 future outlook, 469–470
 consumer studies and
 regulations, 469–470
 tailored design, 469
 microbial evaluation of
 antimicrobial packaging
 effectiveness, 467–469,
 467 *f*–468 *f*, 469*t*
 overview, 462–464, 469–470
 tailoring packaging materials to
 specific food properties,
 463–464
 Antioxidant activity
 high-pressure processing,
 515–517, 515*t*
 pulsed electric fields, 521–523,
 522*t*
Apples
 juice yield in lab-scale, with
 pulsed electric fields,
 192–193, 192 *f*–193 *f*
 pulsed electric fields treatment
 case study, 190–199
 storage in air containing ozone,
 338, 339*t*–340*t*
Aspergillus
 ozone, 298–299, 299*t*
 ultrasound, 145 *f*
 and microbes in combination,
 418
B
Bacillus
 chlorine dioxide, 361–362
 EO water, 369
 high hydrostatic pressure
 and dense-phase carbon dioxide
 in combination, 414*t*–415*t*
 and heat in combination, 407,
 408*t*
 and low pH in combination,
 410
 and pulsed electric fields in
 combination, 420
 and ultrasound in combination,
 420
 high-pressure processing, 58
 magnetic fields, 226*t*–227*t*
 nonthermal plasma, 281, 282*t*, 284
 ozone, 297, 298*t*, 306–308
 pulsed electric fields, 167*t*

- and microbials in combination, 417
- and ultrasound in combination, 420
- pulsed ultraviolet light, 252, 254, 256
- radio frequency electric fields, 219
- ultrasound, 145 *f*
 - and microbials in combination, 417
- Bacteriocins as natural antilisterial food preservatives, 428–446
- Carnobacterium piscicola* strains, 444
- class I bacteriocins, 435–437
 - lacticin 481, 436
 - lacticin 3147, 436–437
 - nisin, 435–436
 - single peptide lantibiotics, 435–436
 - two-peptide lantibiotics, 436–437
- class II bacteriocins, 437–444
 - Carnobacterium piscicola*, 439–440
 - carnocins, 439
 - class IIa bacteriocins, 437–441, 442 *t*
 - class IIb bacteriocins, 441, 443 *t*
 - class IIc bacteriocins, 441–444
 - enterocin AS-48, 441–443
 - enterocin EJ97, 443
 - enterocins, 438
 - lactocin 705, 441
 - lactococcus lactis
 - CCMM/IAV/BK2, 441
 - leucocins, 440
 - pediocins, 437
 - produced by lactobacilli, 440–441
 - reuterin, 443–444
- class III bacteriocins (bacteriolysins), 444
- legislation and management systems to control *Listeria monocytogenes* in foods, 432
- Listeria monocytogenes*, 429
- nonbacteriocin techniques to control *Listeria monocytogenes*, 432–434
- chemical techniques, 434, 434 *t*
- electrolyzed oxidizing water, 433–434
- high pressure, 433
- irradiation, 433
- packaging, 433
- ultrasound and ultraviolet light, 434
- overview, 428–429, 444–446
- prevalence of *Listeria monocytogenes* in foods, 429–432
 - cheeses, 430
 - meat and poultry, 430–431
 - milk, 429–430
 - miscellaneous foods, 431–432
 - seafood, 431
- unclassified bacteriocins, 444, 445 *t*
 - enterocins, 444
 - produced by lactobacilli, 444
- Beef
 - Escherichia coli* 0157:H7 in ground beef, 236–239, 237 *t*, 239 *t*, 241
 - high-pressure processing, 81–82
 - irradiation. *See* Irradiation, beef
- Beer, dense-phase carbon dioxide effects on quality, 355, 355 *f*
- Bernoulli attraction force, 109
- Bioactive compounds, effects of high-pressure processing and pulsed electric fields on, 505–506
- Bioseparation, ultrasonic processing and, 148
- Blanching, 8 *f*, 10, 83
- Boron carbide electrodes, 202–204, 204 *t*, 206, 209–211, 210 *f*, 211 *t*
- Botrytis cinerea*, ozone and, 299
- Brothirix thermosphacta*
 - high hydrostatic pressure and dense-phase carbon dioxide in combination, 414 *t*
- C
- Campylobacter*, high-pressure processing and, 52 *t*
- Candida*
 - chlorine dioxide, 362
 - magnetic fields, 226 *t*
 - nonthermal plasma, 282 *t*
 - ozone, 298–299, 299 *t*
- Carbohydrates
 - high-intensity ultrasonication. *See* High-intensity ultrasonication, physiochemical effects on proteins and carbohydrates
 - high-pressure processing, 75–77
- Carbon dioxide, dense phase, effects on beverage quality, 347–356
 - beer, 355, 355 *f*
 - coconut water, 355–356, 356 *f*
 - future outlook, 356
 - grape juice, 352–355, 353 *t*, 354 *f*, 355 *t*
 - orange juice, 350, 351 *f*–353 *f*, 352
 - overview, 347–348, 356
 - treatment systems, 348–350, 348 *f*–350 *f*
- Carnobacterium piscicola*, 439–440, 444
- Carnocins, 439
- Carotenoids
 - high-pressure processing, 511–514, 512 *t*
 - and pulsed electric fields in combination, 505
 - pulsed electric fields, 520–521
- Carrot juice recovery, pulsed electric fields and, 196–197, 196 *f*
- Casein micelles, high-pressure processing and, 78
- Catfish processing, ozone and, 332–338
- Cavitation, 110–112, 112 *f*, 139–140
- Cheese
 - from high-pressure-treated milk, 79–80
 - prevalence of *Listeria monocytogenes* in, 430

- Chiller water treatment with ozone
for reuse, 319–321, 320*f*
- Chitin, high-intensity ultrasonication
and, 126–128, 127*f*
- Chlorine dioxide, 307, 359–364
calculating concentration,
360–361
overview, 359–360, 360*t*–361*t*,
364
produce industry, 362–364
surface sanitizer, 361–362
- Citrobacter*, high-pressure processing
and, 52*t*
- Class I bacteriocins, 435–437
lacticin 481, 436
lacticin 3147, 436–437
nisin, 435–436
single peptide lantibiotics,
435–436
two-peptide lantibiotics, 436–437
- Class II bacteriocins, 437–444
Carnobacterium piscicola,
439–440
carnocins, 439
class IIa bacteriocins, 437–441,
442*t*
class IIb bacteriocins, 441, 443*t*
class IIc bacteriocins, 441–444
enterocins, 438
enterocin AS-48, 441–443
enterocin EJ97, 443
lactocin 705, 441
lactococcus lactis
CCMM/IAV/BK2, 441
leucocins, 440
pediocins, 437
produced by lactobacilli, 440–441
reuterin, 443–444
- Class III bacteriocins
(bacteriolysins), 444
- Clostridium*
high hydrostatic pressure, 58–60
and irradiation in combination,
419
and low pH in combination, 410
ozone, 297, 308
pressure-assisted thermal
sterilization, 59–60
regulations concerning, 38,
563–564, 568
ultrasound and microbials in
combination, 417
- Coconut water, dense-phase carbon
dioxide effects on quality,
355–356, 356*f*
- Combat rations, 571, 572*f*–573*f*,
585
- Combination processes, novel
technologies in,
379–399
high hydrostatic pressure,
394–399
biological effects, 394–396
combined with antimicrobial
agents, 398
combined with heat, 397–398
combined with ionizing
radiation, 398–399
combined with low pH,
396–397, 397*f*
combined with pulsed electric
fields, 399
ionizing radiation, 386–389
biological effects, 386–387
combined with antimicrobial
agents, 389
combined with modified
atmospheres, 389
combined with temperature,
388–389, 389*f*
overview, 379–381, 399
pulsed electric fields, 390–394
biological effects, 390–391
combined with acidification,
392–393, 393*f*
combined with antimicrobial
agents, 393–394
combined with heat, 391–392,
392*f*
ultrasound, 381–386
biological effects, 382–383
combined with antimicrobial
agents, 385–386
combined with heat, 384–385,
385*f*
combined with pressure,
383–384
- Concurrent validation, 556–557
- Consumer and sensory issues for
development and
marketing, 482–499. *See also* Sensory quality of
pressure-treated foods
consumer risk perception,
482–483, 485–490
control versus lack of control,
483
fatal versus nonfatal hazards,
483
immediate versus delayed risks,
485–486, 485*f*
known versus unknown risks,
485
novel technologies, 486–490,
487*t*, 488*f*, 489*t*, 490*f*
observable versus unobservable
risks, 483, 484*f*, 485
voluntary versus involuntary
risk, 483
emerging technologies, 492–494,
494*f*, 496–499
sensory testing, 496–499
information and consumer
expectations, 490–492,
491*f*, 493*f*
minimizing consumer risk
perceptions, 494–495
overview, 482, 499
product selection criteria,
495–496
- Consumer panels, 498–499
- Consumer trends and perceptions of
novel technologies,
475–480
case study: irradiated food,
479–480
communication with public,
478–479
consumer priorities,
475–476
overview, 475, 480
perceived risks, 476–477
product benefits, 477–478
- Cryptosporidium*, ozone and,
299–300, 300*t*
- Crystalization, ultrasonic processing
and, 141–143, 142*f*
- Curie, Jacques, 135
- Curie, Pierre, 135
- Cyclospora*, ozone and, 299

- D**
- Dairy products, high-pressure processing of, 78–81
- casein micelles, 78
 - cheese and yogurt from
 - high-pressure-treated milk, 79–80
 - milkfat and milk enzymes, 78–79
 - whey proteins, 80–81
- Debaryomyces hansenii*, ozone and, 299
- Decoction, 123
- Decompression time, 7
- Defoaming, power ultrasound and, 149*t*
- Dense-phase carbon dioxide (DPCD)
- combined with high hydrostatic pressure, 413, 414*t*–415*t*, 415–416
 - effects on beverage quality, 347–356
 - beer, 355, 355*f*
 - coconut water, 355–356, 356*f*
 - future outlook, 356
 - grape juice, 352–355, 353*t*, 354*f*, 355*t*
 - orange juice, 350, 351*f*–353*f*, 352
 - overview, 347–348, 356
 - treatment systems, 348–350, 348*f*–350*f*
- Department of Defense Combat Feeding Program, 571
- Descriptive/analytical panels, 497–498
- Dextran, effects of high-intensity ultrasonication on, 126
- Donny Boy, 48
- DPCD (dense-phase carbon dioxide). *See* Dense-phase carbon dioxide (DPCD)
- Dry food and food ingredients, ozone and, 305–306
- E**
- Echigo Seika, 47
- Electrodes
- corrosion, 203–204, 204*t*
 - platinized titanium, 207–209
 - stainless steel, 209
 - surface morphologies, 204–207, 205*f*–210*f*
 - titanium, 207
- Electrohydraulic shock wave (ESW) treatment, 104
- Electrolyzed oxidizing (EO) water, 366–374
- applications, 370–374
 - animal products, 373–374
 - produce, 372–373
 - surface treatment, 370–372
 - electrodialysis and EO water production, 366–367, 367*f*
 - future trends, 374
 - inactivation of suspended cells by, 369–370
 - Listeria monocytogenes*, 433–434
 - overview, 366, 374
 - properties, 367–369
 - acidic EO water, 367–368
 - alkaline EO water, 367
 - generation conditions and effect of storage, 368–369
 - inactivation mode of acidic EO water, 368
 - membrane free
 - electrolysis–neutralized EO water, 368, 369*f*
- Electromagnetic processes
- irradiation. *See* Irradiation
 - nonthermal plasma. *See* Nonthermal plasma
 - oscillating magnetic fields. *See* oscillating magnetic fields
 - pulsed electric fields. *See* Pulsed electric fields
 - pulsed ultraviolet light. *See* Pulsed ultraviolet light
 - radio frequency electric fields. *See* Radio frequency electric fields (RFEF)
 - ultraviolet-C light. *See* Ultraviolet-C light
 - processing of liquid food products
- Emerging technologies, consumer issues about, 492–494, 494*f*, 496–499
- Emulsification, 140–141
- ultrasound, 149*t*
- Enterobacter*
- EO water, 371
 - high-pressure processing, 52*t*, 55
- Enterobacteriaceae*
- high hydrostatic pressure and heat in combination, 408*t*
 - irradiation and low pH in combination, 411
- Enterocins, 438
- enterocin AS-48, 441–443
 - enterocin EJ97, 443
- Enterococcus*
- high hydrostatic pressure and dense-phase carbon dioxide in combination, 414*t*
 - and low pH in combination, 410
- EO water. *See* Electrolyzed oxidizing (EO) water
- Escherichia coli*
- antimicrobial packaging, 468, 468*f*
 - chlorine dioxide, 362
 - EO water, 374
 - high hydrostatic pressure and antimicrobials in combination, 412
 - and dense-phase carbon dioxide in combination, 414*t*
 - and heat in combination, 408
 - and low pH in combination, 411
 - high-pressure processing, 52*t*, 54–57
 - irradiation
 - and modified atmospheres in combination, 389
 - magnetic fields, 226*t*–227*t*, 231–233
 - nonthermal plasma, 278–279, 280*f*, 281, 282*t*, 283–284, 283*f*–284*f*
- O157:H7, 305
- alfalfa seeds, pulsed ultraviolet light and, 256
 - apple juice, nonthermal plasma and, 282–283
 - apple surfaces, ozone and, 304
 - chlorine dioxide, 362–363
 - EO water, 369–372
 - ground beef, 236–239, 237*t*, 239*t*, 241

Escherichia coli (cont.)

- irradiation, 237–239, 239*t*, 241
 - high hydrostatic pressure and heat in combination, 408*t*
 - irradiation, 238–239, 239*t*, 243
 - and microbials in combination, 416
 - ozone, 297, 298*t*, 304, 308
 - pulsed electric fields and acidification in combination, 392–393, 393*f*
 - and heat in combination, 392
 - and low pH in combination, 412
 - salmon fillets, pulsed ultraviolet light and, 256
 - spinach and lettuce, irradiation and, 243
 - ozone, 296, 298*t*, 308
 - pulsed electric fields, 163, 167*t*, 170
 - and heat in combination, 409
 - pulsed ultraviolet light, 254
 - radio frequency electric fields, 219–220, 219*f*
 - strawberries, ozone and, 321, 322*t*–323*t*
 - ultrasound, 144, 146*f*
 - and high hydrostatic pressure in combination, 384
- España (ready-to-eat meat products), 37
- ESW (electrohydraulic shock wave) treatment, 104
- Eurotium*, chlorine dioxide and, 362
- Extraction, power ultrasound and, 149*t*

F

Fish and seafood

- high-pressure processing, 40–41, 81–82
- ozone, 305, 332–338
- prevalence of *Listeria monocytogenes* in, 431

Flavonoids

- high-pressure processing, 505–506, 514
 - pulsed electric fields, 505–506
- Fonterra, 48
- Food additive/food contact concerns, 565–566

Food and Drug Administration, 562–567

Food contact surfaces

- chlorine dioxide, 361–362
 - EO water, 370–372
 - nonthermal plasma, 285
 - ozone, 306
 - ultrasonic processing, 147
- Food Safety Objectives (FSOs), 550, 552–555, 553*f*, 563, 566–568

Food Technology and Safety Laboratory (FTSL), 99

Foster Farms, 45

Freezing and thawing, high-pressure, 8*f*, 9–10, 11*f*

Fresh and fresh-cut fruits and vegetables

- irradiation. *See* Irradiation, fresh and fresh-cut fruits and vegetables
- ozone, 304–305, 330–332, 332*f*

Fresherized Foods (guacamole), 36–37

Fruit juice yield in technical scale pulsed electric fields, 193–196, 194*f*–195*f*FSOs (Food Safety Objectives), 550, 552–555, 553*f*, 563, 566–568

FTSL (Food Technology and Safety Laboratory), 99

Fungi

- antimicrobial packaging, 468*f*
- ozone, 298–299, 299*t*

Future prospects for nonthermal

- processing technologies, 571–592
- applications, 580–589, 580*t*
- high pressure processing, 585–589, 585*f*–588*f*
- pulsed electric fields, 581–584, 581*f*–584*f*, 584*t*

criteria for new technology

- implementation, 578–580
- novel processing technologies, 574–578, 574*t*, 575*f*–577*f*
- overview, 572–574, 572*f*–573*f*, 573*t*, 589–592, 590*f*

G

GAPS (good agricultural practices), 551

Garlic processing plant–spray bar rinse system, ozone and, 317–319

Gelation behavior, effects of high-intensity ultrasonication on, 128–129

Generally recognized as safe (GRAS), 464

Genesis Juice, 213

Geobacillus, high-pressure processing and, 57–58, 60*Giardia*, ozone and, 299–300, 300*t*

Glucosinolates, high-pressure processing and, 514–515

Good agricultural practices (GAPs), 551

Good hygienic practices (GHPs), 551

Good manufacturing practices (GMPs), 551–552

Grain treatment and storage, ozone and, 321–322, 324–326, 325*f*Grape juice, effects of dense-phase carbon dioxide, on quality, 352–355, 353*t*, 354*f*, 355*t*

GRAS (generally recognized as safe), 464

Guacamole, 36–37, 84

H

Halobacterium, magnetic fields and, 226*t**Hansenula anomala*, ozone and, 299Harvested onions, bulk storage and curing, ozone and, 315–316, 315*f*

Hazard analysis critical control point (HACCP), 26, 33, 551–552

- HDP (hydrodynamic pressure processing). *See* Hydrodynamic pressure processing (HDP) of meat products
- Heat, combinations of nonthermal processes and, 397–398, 406–411
- antimicrobials, 412–413
- dense-phase carbon dioxide, 413, 414*t*–415*t*, 415–416
- high hydrostatic pressure, 407–409, 408*t*
- irradiation, 409
- ozone, 307–308
- pulsed electric fields, 391–392, 392*f*, 409–410
- ultrasound, 384–385, 385*f*, 410–411
- High hydrostatic pressure (HHP), 394–399
- and antimicrobial agents in combination, 398
- biological effects, 394–396
- and heat in combination, 397–398, 407–409, 408*t*
- and irradiation in combination, 398–399, 419–420
- and low pH in combination, 396–397, 397*f*, 411
- and modified atmosphere packaging in combination, 418
- and pulsed electric fields in combination, 399, 420
- and ultrasound in combination, 420
- High-intensity ultrasonication, physiochemical effects on proteins and carbohydrates, 109–130
- carbohydrates, 122–129
- chemical changes in, 124–126, 125*f*
- chitin, 126–128, 127*f*
- classical and ultrasound-assisted extraction, 122–123
- dextran, 126
- effect on functionality of, 122
- gelation behavior, 128–129
- immunology, 129
- lignin, 128
- mechanical effects, 123–124
- pectin, 126
- starch, 128
- xyloglucan, 126
- cavitation, 111–112, 112*f*
- enzymatic activity, 121–122
- overview, 109, 129–130, 130*f*
- physics of high-intensity ultrasound, 109–111, 110*f*
- processing parameters, 112–114
- frequency, 113
- intensity, 113
- presence of gases, 113
- pressure, 114
- solvent properties, 113–114
- temperature, 113
- proteins, 117–121
- ability to stabilize emulsions, 120
- effect on functionality of, 117
- foam stabilization, 120–121
- gelation behavior, 120
- modification of surface activity, 117–118, 118*f*
- structural investigations, 118–120, 119*f*
- ultrasonic power, 114–117
- amplitude of ultrasonic wave, direct determination of, 114, 115*f*, 116
- calorimetric determination, 116, 116*f*
- indirect measurements using chemical probes, 116–117
- High-pressure high-temperature (HPHT) treatment, 418
- High-pressure processing (HPP)
- effects on nutritional quality and health-related compounds of fruit and vegetable products, 506–517
- antioxidant activity of fruit and vegetable products, 515–517, 515*t*
- carotenoids, 511–514, 512*t*
- flavonoids, 514
- glucosinolates, 514–515
- vitamins C and B, 507–511, 508*t*, 510*t*
- fact sheet, 595–598
- future prospects, 585–589, 585*f*–588*f*
- Listeria monocytogenes*, 433
- sensory quality of pressure-treated foods. *See* Sensory quality of pressure-treated foods and ultrasound in combination, 383–384
- High-pressure processing (HPP), biochemical aspects of, 72–84
- beef, 81–82
- carbohydrates, 75–77
- dairy products, 78–81
- casein micelles, 78
- cheese and yogurt from high-pressure-treated milk, 79–80
- milkfat and milk enzymes, 78–79
- whey proteins, 80–81
- lipids, 77–78
- overview, 72–73, 84
- pork, 81
- poultry, 81–82
- proteins, 73–75
- seafood, 81–82
- vegetable and fruit quality, 82–84
- water, role of, 73
- High-pressure processing (HPP), case studies of, 36–49
- capital costs and production rates, 42–45, 43*f*–44*f*
- company examples, 45–48
- Abraham Schinken, 46
- AmeriQual, 45
- Donny Boy, 48
- Echigo Seika, 47
- Fonterra, 48
- Foster Farms, 45
- Mitsunori, 48
- Rodilla, 46–47
- SimplyFresco, 46
- by food sector, 39–41, 40*f*
- juices and beverages, 39–40
- meat and poultry products, 40

- High-pressure processing (*cont.*)
 seafood, 40–41
 vegetable products, 40
incentives and constraints, 41–42
overview, 36, 38 *f*–39 *f*, 48
pioneers, 36–37
 Espana (ready-to-eat meat products), 37
 Fresherized Foods (guacamole), 36–37
 Meidi-Ya (cold pasteurized jams), 36
 Ulti (freshly squeezed juices), 36
worldwide applications, 37–39, 41
 companies, 39, 39 *f*
 equipment and its locations, 37–39
 production estimates, 41, 41 *t*
- High-pressure processing (HPP),
 commercialization of, 28–35
 cycle time analysis, 31–32
 determining system requirements, 29–30
 guidelines for product selection, 33–34
 operating costs, 30–31
 overview, 28–29, 34–35
 packaging and material handling factors, 32–33
 product business plan, 29
 product manufacturing
 specifications affecting equipment selection, 33
 product technical plan, 29
- High-pressure processing (HPP),
 equipment for, 20–27
 control systems, 25–26
 laws regulating installation and operation, 26
 operating temperatures, 22–23
 overview, 20, 26–27
 pressure vessels, 20–22
 closures, 22, 23 *f*
 design, 21–22
 materials and construction, 20–21
 pump-intensifiers and supporting high-pressure components, 25, 25 *f*
 vertical, horizontal, and tilting systems, 23, 24 *f*, 25
- High-pressure processing (HPP),
 fundamentals of, 3–17, 596–598
 basic principles, 3–5
 isostatic principle, 4–5
 LeChatelier's principle, 3–4
 overview, 3, 4 *f*, 17, 596–598
 packaging, 5–6
 pressure-temperature response during processing, 6–8
 cycle time, 7
 decompression time, 7
 pressure come-up time, 6–7, 6 *f*
 pressure-holding time, 7
 process pressure, 7
 product initial temperature, 7–8
 pressure-transmitting fluids, 6
 process nonuniformity, minimizing, 16–17
 process uniformity, modeling, 16
 process uniformity during high-pressure processing, 15–16
 properties of food materials under high pressure, 10–15, 12 *f*
 compressibility, 11, 13
 density, 15
 heat of compression, 13–14, 13 *t*–14 *t*
 specific heat, 15
 thermal conductivity, 14
 treatment effects during high-pressure processing, 8–10, 8 *f*
 high-pressure pasteurization, 8
 high-pressure sterilization, 9
 pressure applications during freezing and thawing, 9–10, 11 *f*
 pressure-assisted blanching, 10
 pressure pulsing, 9
 quality of pressure-sterilized products, 9, 10 *f*
 typical process description, 5
- High-pressure processing (HPP),
 microbiological aspects of, 51–66
 bacterial spores, 58
 future research needs, 65–66
 injury and repair, 56
 kinetics, 57–58
 overview, 51, 52 *t*–53 *t*, 65–66
 pressure-assisted thermal sterilization (PATs), 58–60
 pressure-induced inactivation, 54–56
 mechanisms, 54–55
 suspending medium, 55–56
 vegetative bacteria, 51, 53–54
 viruses, 63–65
 effects of HPP on, 62–63, 63 *t*–64 *t*
 mechanisms of pressure inactivation, 63–64
 miscellaneous applications of MPP and viruses, 65
 suspending medium, 64–65
 virus surrogates, 65
 yeasts and molds, 60–63
 activation and germination of ascospores by HPP, 61–62
 effects of HPP on, 60–61
 process implications for controlling, 62–63
 suspending medium, 62
- HPHT (high-pressure high-temperature)
 treatment, 418
- HPP. *See* High-pressure processing entries
- Hydrodynamic pressure processing (HDP) of meat products, 98–106
 and antimicrobial interventions in combination, 103–104
 food-borne pathogens, 103
 future research opportunities, 104–106, 105 *f*
 history and origin of hydrodynamic pressure processing, 98
 meat tenderization, 99–102
 microbial safety, 102–103

- overview, 98, 104–106
- shelf life extension, 104
- Hydrodyne process and equipment, 98
- Hydrogen peroxide, combined with ozone, 307
- Hydrophobic effects of high-pressure treatment, 72–73
- I
- Iceberg lettuce, irradiation of, 614–616
- ICR (ion cyclotron resonance) model, 229–230, 230*f*
- Immunology, effects of
 - high-intensity ultrasonication on, 129
- Industrial evaluation of nonthermal technologies, 537–543
- hurdles, understanding, 538–543
 - decision process, 542–543, 542*f*
 - food processing patents, 541–542
 - incomplete or debatable data, 538–539, 539*f*
 - justified investments, 539–540
 - location, 541
 - miscellaneous stakeholders, 540–541
 - regulatory and legislative disharmony, 542
 - scaling up, 539
 - weak business case, 540
- overview, 537–538, 543
- Integrated food safety management systems, 551–553, 552*f*–553*f*
- Ion cyclotron resonance (ICR) model, 229–230, 230*f*
- Ion parametric resonance (IPR) model, 230–231
- Irradiation, 236–245, 386–389, 611–616
 - and antimicrobial agents in combination, 389, 416
 - beef
 - consumer acceptance and sales, 240–241
 - cooking temperature, meat thermometers, and risk, 241
 - heat sensitivity following irradiation, 241–243, 242*f*
 - inactivation of *E. coli* O157:H7, 238–239, 239*t*
 - irradiation in the United States, 237
 - organoleptic quality, 239–240
 - recalls, 237*t*
 - toxicological safety, 237–238
- biological effects, 386–387
- fact sheets, 611–616
- fresh and fresh-cut fruits and vegetables, 243–245
- iceberg lettuce and spinach, 614–616
- packaging materials, 245
- pathogen reduction, 243
- quality, 243–244
- regulatory approval, 244
- safety, 244–245
- and high hydrostatic pressure in combination, 398–399, 419–420
- Listeria monocytogenes*, 433
- and low pH in combination, 411
- and low temperature and modified atmosphere packaging in combination, 418–419
- and modified atmospheres in combination, 389
- overview, 236–237, 237*t*, 245, 611–616
- and temperature in combination, 388–389, 389*f*, 409, 418–419
- Isostatic principle, 4–5
- J
- Juices and beverages, high-pressure processing of, 39–40
- K
- Kluyveromyces marxianus*, ozone and, 299
- L
- Labeling issues of concern, 566–567
- Lactacin 481, 436
- Lactacin 3147, 436–437
- Lactobacillus*
 - chlorine dioxide, 362
 - high hydrostatic pressure and dense-phase carbon dioxide in combination, 414*t*
 - high-pressure processing, 53*t*
 - ozone, 308
 - pulsed electric fields, 163
 - radio frequency electric fields, 218
- Lactocin 705, 441
- Lactococcus*, high-pressure processing and, 52*t*
- LeChatelier's principle, 3–4
- Legionella*
 - high hydrostatic pressure and dense-phase carbon dioxide in combination, 414*t*
 - ozone, 298*t*
- Lettuce, irradiation of, 614–616
- Leucocins, 440
- Leuconostoc mesenteroides*
 - chlorine dioxide, 362
 - ozone, 297
- Lignin, effects of high-intensity ultrasonication on, 128
- Lipids, high-pressure processing and, 77–78
- Listeria*, 379
 - bacteriocins and. *See* Bacteriocins as natural antilisterial food preservatives
 - chlorine dioxide, 362–363
 - EO water, 369–373, 433–434
 - FDA guidelines, 38, 40
 - high hydrodynamic pressure processing, 103
 - high hydrostatic pressure and antimicrobials in combination, 412–413
 - and dense phase carbon dioxide in combination, 414*t*
 - and heat in combination, 408*t*, 409
 - and low pH in combination, 411
 - and ultrasound in combination, 420

Listeria (cont.)

- high-pressure processing, 52*t*, 54–57, 433
- irradiation, 241, 433
 - and microbials in combination, 416
- nicin, 467, 467 *f*
- nonthermal plasma, 279, 283–284
- ozone, 297, 298*t*, 308
- packaging, 433
- pulsed electric fields, 167*t*, 308
 - and heat in combination, 392–393, 392 *f*–393 *f*
 - and microbials in combination, 417
- pulsed ultraviolet light, 254, 256
- ultrasound, 144, 145 *f*, 434
 - and high hydrostatic pressure in combination, 384
 - and low a_w in combination, 419
- ultraviolet light, 434
- Low a_w , combined with ultrasound, 419
- Low pH
 - combined with high hydrostatic pressure, 396–397, 397 *f*
 - high hydrostatic pressure and, 396–397, 397 *f*, 411
 - irradiation and, 411
 - pulsed electric fields and, 411–412
 - ultrasound and, 412
- Low temperature, combined with
 - irradiation and modified atmosphere packaging, 418–419

M

- Maceration, 123
- Magnetostrictive transducers, 136
- MAP (modified atmosphere packaging)
 - combined with HHP, 418
 - combined with irradiation and low temperature, 418–419
- Meat products
 - beef. *See* Beef
 - high-pressure processing, 40, 81
 - hydrodynamic pressure processing. *See* Hydrodynamic pressure

- processing (HDP) of meat products
- ozone, 326–327, 327*t*, 328 *f*
- prevalence of *Listeria monocytogenes* in, 430–431
- Meidi-Ya (cold pasteurized jams), 36
- Microbiological risk assessment, risk management, and process validation tools, 550–561
- good manufacturing practices (GMPs), 551–552
- hazard analysis critical control point (HACCP), 551–552
- integrated food safety management systems, 551–553, 552 *f*–553 *f*
- microbiological risk assessment and risk management, 550–551
- overview, 550, 560–561
- performance, process, and product criteria, 553–555
- process validation methodology, 555–559, 556 *f*
 - concurrent validation, 556–557
- equipment installation qualification, 557
- process performance qualification, 557–558
- product performance qualification, 557
- prospective validation, 557
- retrospective validation, 557
- step-wise approach, 558–559
- variation and validation, 559–560, 559 *f*–560 *f*

Micrococcus

- ozone, 306
- pulsed electric fields and low pH in combination, 412
- and microbials in combination, 417

Micronutrients, effects of

- high-pressure processing and pulsed electric fields on, 503–505

Milk

- milkfat and milk enzymes, high-pressure processing of, 78–79
- prevalence of *Listeria monocytogenes* in, 429–430
- Minerals, effects of high-pressure processing and pulsed electric fields on, 504–505
- Mitsunori, 48
- Modified atmosphere packaging (MAP)
 - combined with HHP, 418
 - combined with irradiation and low temperature, 418–419
- Modified atmospheres, combined with ionizing radiation, 389
- Molds, 60–63
 - high-pressure processing, 60–62
 - magnetic fields, 227*t*
- Mycobacterium*, high-pressure processing and, 53*t*

N

- Naegleria gruberi*, ozone and, 299, 300*t*
- Nisin, 435–436
- NLEA (Nutritional Labeling and Education Act), 574
- Nonthermal plasma (NTP), 271–286
 - antimicrobial efficacy, 276, 277 *f*, 278–285
 - direct treatment (“active plasma”) technologies, 278–280, 280 *f*–281 *f*
 - electrode contact treatments, 280–284, 282*t*, 283 *f*
 - feed gas composition, 284–285, 284 *f*
 - remote treatment (“afterglow”) technologies, 276, 277 *f*, 278
 - economic analysis, 285–286
 - food contact surfaces, 285
 - future research, 286
 - overview, 271–272, 286
 - physical and chemical properties, 272–273

- plasma physics primer, 273–274
- sterilization, 274–276
 - mechanism of microbial inactivation, 274
 - technologies, 274–276, 275*t*
- Nonthermal processes as hurdles, 406–421
 - combinations of irradiation with
 - low temperature and modified atmosphere packaging, 418–419
 - combinations of nonthermal processes, 411–413, 415–420
 - high hydrostatic pressure and antimicrobials, 412–413
 - high hydrostatic pressure and dense-phase carbon dioxide, 413, 414*t*–415*t*, 415–416
 - high hydrostatic pressure and irradiation, 419–420
 - high hydrostatic pressure and low pH, 411
 - high hydrostatic pressure and modified atmosphere packaging, 418
 - high hydrostatic pressure and pulsed electric fields, 420
 - high hydrostatic pressure and ultrasound, 420
 - irradiation with antimicrobials, 416
 - irradiation with low pH, 411
 - pulsed electric fields with
 - antimicrobials, 416–417
 - pulsed electric fields with low pH, 411–412
 - pulsed electric fields with
 - ultrasound, 420
 - ultrasound and antimicrobials, 417–418
 - ultrasound and low a_w , 419
 - ultrasound and low pH, 412
- combinations of nonthermal processes and heat, 406–411
 - high hydrostatic pressure and heat, 407–409, 408*t*
 - irradiation and heat, 409
 - pulsed electric fields and heat, 409–410
 - ultrasound and heat, 410–411
- conclusions, 420–421
- overview, 406, 407*t*
- Novel processing technologies
 - consumer risk perception, 486–490, 487*t*, 488*f*, 489*t*, 490*f*
 - future prospects, 574–578, 574*t*, 575*f*–577*f*
- NTP. *See* Nonthermal plasma
- Nutritional Labeling and Education Act (NLEA), 574
- Nutritional quality and health-related
 - compounds of fruit and vegetable products, effects of high-pressure processing and pulsed electric fields on, 502–530
 - antioxidant activity of fruit and vegetable products, 515–517, 515*t*
 - effects of high-pressure processing, 506–517
 - carotenoids, 511–514, 512*t*
 - flavonoids, 514
 - glucosinolates, 514–515
 - vitamins C and B, 507–511, 508*t*, 510*t*
 - effects of pulsed electric fields
 - antioxidant activity, 521–523, 522*t*
 - carotenoids, 520–521
 - phenolic compounds, 521
 - vitamin C, 517–520, 518*t*, 519*f*
 - health-related properties, 523–524, 525*t*, 526*f*–529*f*, 525–527, 529–530*t*
 - nutrients and bioactive
 - compounds, 503–506
 - bioactive compounds, 505–506
 - carotenoids, 505
 - flavonoids, 505–506
 - micronutrients, 503–505
 - minerals, 504–505
 - organosulfur compounds, 506
 - phytosterols, 506
 - vitamins, 503–504
 - overview, 502–503, 527–530
- O
- Ohenolic compounds, pulsed electric fields and, 521
- One atmosphere uniform glow discharge plasma (OAUGDP), 276, 282*t*
- Orange juice, effects of dense-phase carbon dioxide on quality, 350, 351*f*–353*f*, 352
- Organosulfur compounds, effects of high-pressure processing and pulsed electric fields on, 506
- Oscillating magnetic fields (OMFs), 222–234
 - applications, 232–233
 - critical process factors, 231–232
 - electrical resistivity, 231–232
 - magnetic field characteristics, 231
 - microbial growth stage, 232
 - temperature, 232
 - living cells, effects of magnetic fields on, 224–225, 226*t*–227*t*, 227–228
 - magnetic fields, 222–224
 - generation of, 223–224, 224*f*
 - microbial inactivation, methods of, 228–231, 229*f*–230*f*
 - overview, 222, 233–234
 - research needs, 233–234
- Oseen pressure, 109
- Ozone, 291–309, 314–340, 603–610
 - antimicrobial properties, 296–300
 - bacteria, 297–298, 298*t*
 - fungi, 298–299, 299*t*
 - protozoa, 299–300, 300*t*
 - viruses, 300, 301*t*
 - applications, 300–307, 314–340
 - apple storage in air containing ozone, 338, 339*t*–340*t*
 - catfish processing, 332–338
 - dry food and food ingredients, 305–306
 - fish and seafood, 305
 - food properties and ozone applicability, 300–302, 302*f*
 - fresh-cut lettuce, salads, and vegetables, 330–332, 332*f*

Ozone (*cont.*)

fruits and vegetables, 304–305
 garlic processing plant–spray
 bar rinse system, 317–319
 grain treatment and storage,
 321–322, 324–326, 325 *f*
 harvested onions, bulk storage
 and curing of, 315–316,
 315 *f*
 meat products, 326–327, 327*t*,
 328 *f*
 ozone as alternative sanitizer in
 food processing, 302
 ozone treatment systems,
 302–304, 303 *f*
 packaging material and food
 contact surfaces, 306
 position of the IOA, 314–315
 potatoes, 316
 poultry drinking water, 327, 329
 raw poultry and meats, 305
 removal of pesticides from
 agricultural commodities,
 306–307
 shell eggs, 305
 strawberries and frozen
 strawberry topping, 321,
 322*t*–323*t*
 tomatoes grown hydroponically
 in ozone-containing water,
 317
 treatment of chiller water for
 reuse, 319–321, 320 *f*
 chemistry and physics, 291–294,
 292 *f*, 292*t*
 reactivity, 294, 294 *f*
 solubility, 292–293, 293 *f*
 stability, 293–294
 combination treatments, 307–308
 with chlorine, 307
 with heat, 307–308
 with hydrogen peroxide, 307
 with other gases, 307
 with pulsed electric fields, 308
 with UV radiation, 308
 commercialization, 342–346
 emergency shut-off switches,
 345
 feed gas, 342–343
 filtration, 345

monitoring, 345
 ozone contact/transfer,
 343–344, 344 *f*
 ozone generator, 343, 343 *f*
 power supply, 342, 345
 safety, 344–345, 345*t*
 system concept, 342
 fact sheet, 603–610
 limitations, safety considerations,
 and regulatory status,
 308–309
 measurement, 295–296
 aqueous phase, 295–296, 296 *f*
 gaseous phase, 296
 overview, 291, 308–309,
 603–610
 production, 295, 295 *f*

P

Packaging

antimicrobial, 462–470
 antimicrobial compounds and
 methods of incorporation
 in packaging materials,
 464–466, 465*t*, 466 *f*
 direct contact and transfer by
 migration systems,
 462–463, 463*t*
 future outlook, 469–470
 consumer studies and
 regulations, 469–470
 tailored design, 469
 microbial evaluation of
 antimicrobial packaging
 effectiveness, 467–469,
 467 *f*–468 *f*, 469*t*
 overview, 462–464, 469–470
 tailoring packaging materials to
 specific food properties,
 463–464
 high-pressure processing, 5–6
 irradiation, 245
Listeria monocytogenes, 433
 ozone, 306

Panels

consumer panels, 498–499
 descriptive/analytical panels,
 497–498

Pasteurization, high-pressure, 8, 8 *f*

Patents, food processing, 541–542

PATP (pressure-assisted thermal
 processing), 9

PATS (pressure-assisted thermal
 sterilization), 9, 33

Pectin, effects of high-intensity
 ultrasonication on, 126

Pediocins, 437

Penicillium

chlorine dioxide, 362

EO water, 370

ozone, 299

ultrasound and microbials in
 combination, 418

Percolation, 123

Pesticides, removal from agricultural
 commodities with ozone,
 306–307

Physical processes

high-intensity untrasonication. *See*

High-intensity
 ultrasonication,
 physiochemical effects on
 proteins and carbohydrates

high pressure. *See* High-pressure
 processing

hydrodynamic. *See* Hydrodynamic
 pressure processing (HDP)
 of meat products

ultrasonic. *See* Ultrasonic
 processing

Phytosterols, effects of high-pressure
 processing and pulsed
 electric fields on, 506

Pichia farinose, ozone and, 299

Piezoelectric transducers, 136

Platinized titanium electrodes,
 202–205, 204*t*,
 206 *f*–207 *f*, 207–208,
 211*t*

Pork, high-pressure processing of,
 81

Potatoes, ozone and, 316

Poultry

drinking water, ozone treatment
 of, 327, 329

high-pressure processing, 40,
 81–82

prevalence of *Listeria*
monocytogenes in,
 430–431

- Pressure-assisted thermal processing (PATP), 9
- Pressure-assisted thermal sterilization (PATS), 9, 33, 58–60
- Pressure come-up time, 6–7, 6*f*
- Pressure-holding time, 7
- Pressure-transmitting fluids, 6
- Pressure vessels, 20–22
 - closures, 22, 23*f*
 - design, 21–22
 - materials and construction, 20–21
- Process performance qualification, 557–558
- Process pressure, 7
- Process validation methodology, 555–559, 556*f*
 - concerns, 567–570
 - concurrent validation, 556–557
 - equipment installation qualification, 557
 - process performance qualification, 557–558
 - product performance qualification, 557
 - prospective validation, 557
 - retrospective validation, 557
 - step-wise approach, 558–559
- Produce
 - chlorine dioxide, 362–364
 - EO water, 372–373
 - irradiation. *See* Irradiation, fresh and fresh-cut fruits and vegetables
 - ozone, 304–305, 330–332, 332*f*
- Proteins
 - high-intensity ultrasonication. *See* High-intensity ultrasonication, physiochemical effects on proteins and carbohydrates
 - high-pressure processing, 73–75
- Proteus vulgaris*, and high hydrostatic pressure and dense-phase carbon dioxide in combination, 414*t*
- Protozoa, ozone and, 299–300, 300*t*
- Pseudomonas*
 - chlorine dioxide, 362
- EO water, 371
- high hydrostatic pressure
 - and dense-phase carbon dioxide in combination, 414*t*
 - and low pH in combination, 411
- high-pressure processing, 53*t*, 56
- irradiation and microbials in combination, 416
- magnetic fields, 226*t*
- nonthermal plasma, 282*t*
- ozone, 297
- pulsed electric fields, 167*t*
 - and low pH in combination, 412
- pulsed ultraviolet light, 254
- Pulsed electric fields (PEFs), 390–394
 - and acidification in combination, 392–393, 393*f*
 - and antimicrobial agents in combination, 393–394
 - and antimicrobials in combination, 416–417
 - biological effects, 390–391
 - effects on nutritional quality and health-related compounds of fruit and vegetable products
 - antioxidant activity, 521–523, 522*t*
 - carotenoids, 520–521
 - phenolic compounds, 521
 - vitamin C, 517–520, 518*t*, 519*f*
 - future prospects, 581–584, 581*f*–584*f*, 584*t*
 - and heat in combination, 391–392, 392*f*, 409–410
 - and high hydrostatic pressure in combination, 399, 420
 - industrial evaluation, 538–539
 - and low pH in combination, 411–412
 - and ozone in combination, 308
 - and ultrasound in combination, 420
- Pulsed electric fields (PEFs), assisted extraction case study, 190–199
 - application examples, 191–197
 - anthocyanin extraction, 197, 197*f*
 - apple juice yield in lab-scale, 192–193, 192*f*–193*f*
 - carrot juice recovery, 196–197, 196*f*
 - fruit juice yield in technical scale, 193–196, 194*f*–195*f*
 - tissue integrity, 191–192, 191*f*
 - cost estimation, 197–199, 198*f*, 198*t*
 - industrial scale equipment, 199, 199*f*, 199*t*
 - overview, 190–191
- Pulsed electric fields (PEFs), engineering aspects of, 176–188
 - conductivity and intrinsic electrical resistance, 182–183, 182*f*
 - controlling and monitoring, 183
 - electrical components, 177–182
 - electric field intensity, 180–182
 - power supply, 177
 - pulse shape, 177–178
 - switch, 178
 - treatment chamber, 178–180, 180*f*
- fluid flow in coaxial treatment chamber design, 184–186, 185*f*
- overview, 176–177, 188
- specific energy and temperature, 183–184, 184*f*, 184*t*
- system efficiency, 186–188, 186*t*, 187*f*–188*f*
- Pulsed electric fields (PEFs), processing basics of, 157–171, 599–602
 - design limitations and challenges, 166
 - economical and environmental considerations, 169–171
 - fact sheet, 599–602
 - future needs, 171
 - mechanisms of action, 158–160
 - cell electroporation, 158–159
 - on food components, 159–160
 - overview, 157, 171, 599–602
 - potential applications, 166–167, 169

- Pulsed electric fields (*cont.*)
 liquid foods, 166–167, 167*t*–168*t*, 169
 solid foods, 169
 process engineering, 160–162, 161*f*
 electrical properties of food products, 160
 treatment considerations, 160–162
 processing critical parameters, 162–164
 food intrinsic parameters, 162–163
 processing system and environmental parameters, 163–164
 systems, 164–165, 165*f*
- Pulsed electric fields (PEFs)
 chamber, improving electrode durability by selecting suitable material, 201–211
 boron carbide electrodes, 209–211
 materials and methods, 202–204
 electrode corrosion analysis, 203
 experimental procedure, 203
 materials, 202
 media, 202
 statistical analysis, 203–204
 treatment system, 202–203, 202*f*
 overview, 201–202, 211
 results and discussion, 204–211
 electrode corrosion, 204, 204*t*
 electrode surface morphologies, 204–207, 205*f*–210*f*
 platinized titanium electrodes, 207–209
 titanium electrodes, 207
 toxicity of migrated element amounts, 211, 211*t*
 stainless steel electrodes, 209
- Pulsed ultraviolet light, 249–259, 617–620
 applications, 254–257
 economics, 258–259
 effect on food components and quality, 257–258
 fact sheet, 617–620
 future trends, 259
 inactivation mechanism, 251–253, 253*f*
 overview, 249–251, 250*t*–251*t*, 251*f*, 259, 617–620
 pathogen inactivation modeling, 258
 UV-light penetration and absorption, 253–254
- Pump–intensifiers, 25, 25*f*
- Q
 Quality
 definition, 89–90
 validation of, 91–93, 91*f*–93*f*, 94*t*, 95*f*
- R
 Radio frequency electric fields (RFEFs)
 applications, 219
 challenges, 219–220
 generation of RFEF fields, 215–216
 historical background, 213
 main processing parameters, 218–219
 electric field strength, 218, 218*f*
 treatment temperature, 218, 218*t*
 treatment time, 218–219, 219*f*
 mechanisms of action, 214
 operating costs, 220
 overview, 213, 220–221
 regulations, 220
 treatment chamber design, 216–217, 216*f*–217*f*
 treatment systems, 214–215, 214*f*–215*f*
- Radio Frequency Identification (RFID) tags, 26
- Regulations and alternative food-processing technologies, 562–570
 food additive/food contact concerns, 565–566
 labeling issues of concern, 566–567
 organism of concern, 563–565
 overview, 542, 562–563, 570
 process validation concerns, 567–570
 responsibilities, 570
- Retrospective validation, 557
- Reuterin, 443–444
- RFEFs (radio frequency electric fields). *See* Radio frequency fields (RFEFs)
- RFID (Radio Frequency Identification) tags, 26
- Rodilla, 46–47
- S
Saccharomyces cerevisiae
 chlorine dioxide, 362
 high hydrostatic pressure and low pH in combination, 411
 magnetic fields, 226*t*, 227–228, 232
 nonthermal plasma, 282*t*
 pulsed electric fields, 163
 and low pH in combination, 412, 415*t*
 radio frequency electric fields, 218–220
 ultrasound, 145*f*
 and heat in combination, 410
 and microbials in combination, 417
 UV light, 268, 268*f*
- Saccharomyces rosei*, ozone and, 299
- Safety
 irradiation, 244–245
 ozone, 308–309, 344–345, 345*t*
- Salmonella*
 antimicrobial packaging, 468
 chlorine dioxide, 362–363
 EO water, 369–372
 high hydrostatic pressure and dense-phase carbon dioxide in combination, 414*t*
 and heat in combination, 408*t*, 409
 and pulsed electric fields in combination, 420
 high-pressure processing, 53*t*
 irradiation, 241–243, 242*f*

- and antimicrobial agents in combination, 389, 416
- and low pH in combination, 411
- and temperature in combination, 388
- ozone, 297, 298*t*, 305
- pulsed electric fields, 167*t*
- ultrasound and heat in combination, 385, 385*f*
- Sanitary and Phytosanitary (SPS) Agreement, 551
- Seafood
 - high-pressure processing, 40–41, 81–82
 - prevalence of *Listeria monocytogenes* in, 431
- Sensory quality of pressure-treated foods, 89–96. *See also* Consumer and sensory issues for development and marketing
 - creating quality, 90–91
 - measurement examples, 95–96, 96*f*
 - overview, 89–90
 - process and product improvements, 93, 95
 - “quality,” meaning of, 89–90
 - validation of quality, 91–93, 91*f*–93*f*, 94*t*, 95*f*
- Serratia marcescens*
 - magnetic fields, 226*t*–227*t*, 228
 - pulsed electric fields and low pH in combination, 412
- Shell eggs, ozone and, 305
- Shewanella oneidensis*, magnetic fields and, 227*t*, 228
- Shigella*
 - high-pressure processing, 53*t*
 - ozone, 297, 298*t*
- SimplyFresco, 46
- Single-peptide lantibiotics, 435–436
- SMFs (static magnetic fields), 223
- Solvent extraction, ultrasonic processing and, 143, 143*t*
- Spinach, irradiation of, 614–616
- SPS (Sanitary and Phytosanitary) Agreement, 551
- Stainless steel electrodes, 202–204, 204*t*, 206, 208*f*–209*f*, 209, 211*t*
- Staphylococcus*
 - antimicrobial packaging, 468
 - chlorine dioxide, 362
 - EO water, 371–372
 - high hydrostatic pressure and antimicrobials in combination, 412
 - and dense-phase carbon dioxide in combination, 414*t*
 - and heat in combination, 408, 408*t*
 - and low pH in combination, 397, 397*f*, 410
- high-pressure processing, 53*t*, 55–57
- irradiation, 241
 - and temperature in combination, 388, 389*f*
- magnetic fields, 226*t*, 228
- nonthermal plasma, 278, 282*t*, 284, 284*f*
- pulsed electric fields, 167*t*
- pulsed ultraviolet light, 254–255
- Starch, effects of high-intensity ultrasonication on, 128
- Static magnetic fields (SMFs), 223
- Sterilization
 - high-pressure, 8*f*, 9
 - nonthermal plasma (NTP), 274–276
- Stokes force, 109
- Strawberries and frozen strawberry topping
 - ozone, 321, 322*t*–323*t*
- Streptococcus*, magnetic fields and, 226*t*
- Surfaces, food contact
 - chlorine dioxide, 361–362
 - EO water, 370–372
 - nonthermal plasma, 285
 - ozone, 306
 - ultrasonic processing, 147
- T
- Technical Barriers to Trade (TBT) Agreement, 551
- Titanium electrodes, 202–205, 204*t*, 207, 211*t*
- Tomatoes grown hydroponically in ozone-containing water, 317
- Transferring emerging food technologies into the marketplace, 544–549
 - overview, 544–545, 549
 - strategies, 545–546, 545*t*
 - tactics, 546–549
 - build sustainability in customer companies, 548
 - facilitate R&D and innovation to reduce cost, uncertainty, and risk, 548–549
 - focus in areas where “barriers-to-entry” are lowest, 546–547
 - obtain and analyze relevant intelligence, 547–548
- Two-peptide lantibiotics, 436–437
- U
- Ulti (freshly squeezed juices), 36
- Ultrasonic processing, 135–150, 621–625. *See also* Ultrasound
 - acoustic cavitation, 139–140
 - enhancing cavitation activity, 140
 - stable (static) cavitation, 139–140
 - transient cavitations, 139
 - bioseparation, 148
 - cleaning and surface decontamination, 147
 - fact sheet, 621–625
 - generation of ultrasound and ultrasound systems, 135–138
 - magnetostrictive transducers, 136
 - mechanical methods, 135
 - new reactors, 137–138
 - piezoelectric transducers, 136
 - probe system, 136–137, 137*f*
 - tank system, 137
 - ultrasound generation, 135
- glossary, 150

- Ultrasonic processing (*cont.*)
 heat and mass transfer,
 ultrasonically enhanced,
 147–148
 inactivation of microorganisms,
 144, 145 *f*–146 *f*, 146–147
 overview, 135, 148–150, 621–625
 power ultrasound applications,
 140–143, 148–150, 149 *f*,
 149 *t*
 crystalization, 141–143, 142 *f*
 emulsification, 140–141
 size reduction, 141
 solvent extraction, 143, 143 *t*
 ultrasound measurement,
 138–139, 139 *f*
 Ultrasound, 381–386. *See also*
 High-intensity
 ultrasonication,
 physiochemical effects on
 proteins and carbohydrates;
 Ultrasonic processing
 and antimicrobial agents in
 combination, 385–386,
 417–418
 biological effects, 382–383
 and heat in combination, 384–385,
 385 *f*, 410–411
 and high hydrostatic pressure in
 combination, 383–384, 420
 and low a_w in combination, 419
 and low pH in combination, 412
 and ultraviolet light in
 combination, 434
 Ultraviolet-C (UV-C) light
 processing of liquid food
 products, 262–269
 applications, 264–265
 air, 265
 liquid food, 264–265
 surfaces, 265
 water, 265
 dosage measurement, 267
 equipment, 265–266, 266 *f*
 microbial inactivation and DNA,
 262–264, 264 *f*
 modeling, 267–269
 decimal reduction dose,
 268–269 *t*
 dosage, 268
 first-order kinetics modeling,
 268, 268 *f*
 UV-C light absorption in
 liquids, 267–268, 268 *t*
 overview, 262, 263 *f*, 264 *t*,
 269
 and ozone in combination,
 308
 UV light penetration into liquid
 food products, 264
 variables, 267
 density and type of
 microorganisms,
 267
 flow behavior and flow rate, 267
 geometric configuration, 267
 type of liquid and UV-C
 absorptivity, 267
 UV-C mercury lamps, 267
 US Army Soldier Research and
 Development Center, 751
- V
 Variation and validation, 559–560,
 559 *f*–560 *f*
 Vegetables
 high-pressure processing, 40,
 82–84
 irradiation. *See* Irradiation, fresh
 and fresh-cut fruits and
 vegetables
 ozone, 304–305, 330–332, 332 *f*
Vibrio, high-pressure processing and,
 53 *t*
 Viruses, 63–65
 high-pressure processing, 62–63,
 63 *t*–64 *t*, 65
 mechanisms of pressure
 inactivation, 63–64
 ozone, 300, 301 *t*
 suspending medium, 64–65
 virus surrogates, 65
- Vitamins
 effects of high-pressure processing
 and pulsed electric fields
 on, 503–504
 vitamin B, 507–511, 508 *t*,
 510 *t*
 vitamin B1, B2, B3, B6, folate,
 504
 vitamin C, 504, 507–511, 508 *t*,
 510 *t*, 517–520, 518 *t*,
 519 *f*
 vitamin E, 504
- W
 Whey proteins, high-pressure
 processing and, 80–81
- X
 Xyloglucan, effects of high-intensity
 ultrasonication on, 126
- Y
 Yeasts, 60–63
 high-pressure processing,
 60–62
 magnetic fields, 227 *t*
Yersinia, 379
 chlorine dioxide, 362
 high hydrostatic pressure and
 ultrasound in combination,
 420
 high-pressure processing, 53 *t*,
 57
 ozone, 297, 298 *t*
 pulsed electric fields, 167 *t*
 ultrasound, 383
 and heat in combination, 410
 Yogurt from high-pressure-treated
 milk, 79–80
- Z
Zygosaccharomyces bailii, ozone
 and, 298, 299 *t*
Zygosaccharomyces rouxii
 ultrasound and microbials in
 combination, 417