APPENDIX A

ANNOTATED BIBLIOGRAPHY ON FOOD SAFETY PROBLEMS AND RECOMMENDED PREVENTIVE CONTROLS

Table A-1: Summary of Literature Findings on Microbiological Safety Issues and Preventive Controls

Source	Industry/Products	Problem/Risk	Preventive Controls Suggested
AMI, 2003	Meat and poultry	Manufacturing equipment design	The processing equipment should be of sanitary design. ▪ It must be cleanable down to the microbiological level ▪ It must be made of compatible materials ▪ It must be accessible for inspection, maintenance, cleaning, and sanitation ▪ It must be self-draining (i.e., does not allow for product or liquid collection) ▪ It must have its hollow areas hermetically sealed ▪ It must be free of niches ▪ It must have sanitary operational performance ▪ It must have its maintenance enclosures hygienically designed ▪ It must be hygienically compatible with other plant systems ▪ It must have a validated cleaning and sanitizing protocol
BBC News, 2002	Prepared foods	Cooks and chefs with long and/or artificial finger nails	Short and clean finger nails
Beauchat and Ryu, 1997	Fresh produce	Pathogen contamination through ▪ Contact with soil, raw or improperly composted manure, irrigation water containing untreated sewage, or contaminated wash water ▪ Contact with animals, insects, unpasteurized products of animal origin, and contaminated surfaces	▪ Treatment of produce with chlorinated water (may not eliminate pathogens completely) ▪ Control of potential points of contamination in the field, during harvesting, processing and distribution, retail markets, at food-service facilities, and at home
Bell and Kyriakides, 2002a	Not specified	Not specified	▪ Effective hygiene ▪ Routine pathogen monitoring ▪ Steam pasteurization ▪ GAPs ▪ Microbiological testing ▪ Chlorine washing ▪ Challenge studies to determine the critical control points ▪ Segregation of raw materials from in-process and finished products ▪ Effective cleaning and disinfection

Table A-1: Summary of Literature Findings on Microbiological Safety Issues and Preventive Controls

Source	Industry/Products	Problem/Risk	Preventive Controls Suggested
Bell and Kyriakides, 2002b	Not specified	Not specified	▪ Controlling the feed of food animals and poultry ▪ Effective hygiene ▪ Routine pathogen monitoring ▪ Steam pasteurization ▪ GAPs ▪ Microbiological testing ▪ Chlorine washing ▪ Challenge studies to determine the critical control points ▪ Segregation of raw materials from in-process and finished products ▪ Effective cleaning and disinfection
Bell and Kyriakides, 2002c	Raw and processed foods	▪ Product manufactured with no processing stage to kill the organism ▪ Product with few or no preservatives ▪ Post-process contamination ▪ Poor personnel handling practices	▪ Monitoring and testing the product ▪ Washing produce with chlorine ▪ Segregation of raw and processed materials ▪ Effective cleaning and sanitation ▪ Environmental sampling and cleaning ▪ Routine monitoring of cleaning efficiency
Belluck and Drew, 1998	Lettuce	▪ Open shed ▪ Unchlorinated wash water ▪ Unsanitary employee practices	Not specified
Berne, 1997	All foods	Not specified	▪ Good employee hygiene ▪ Ensurance of adequate hand washing through the use of automated hand washing systems ▪ Use of color-coded cleaning materials ▪ Use of pathogen detection and cleaning validation testing systems
Best, 2000	Meat and eggs	In-plant construction activities	▪ Avoidance of sample compositing during testing ▪ Testing during operations to reflect true-life conditions ▪ Nonrandomized testing ▪ Vaccination ▪ Competitive exclusion ▪ In-the-shell pasteurization
Brandt, 1999	Hot dogs	Risk of post-processing contamination with *Listeria monocytogenes*	▪ Revised plant procedures ▪ Packaging innovations ▪ Addition of key ingredients, such as sodium nitrite, sodium lactate, sodium diacetate, polyphosphates, organic acids, smoke flavoring, and bacteriocins, such as nisin and pediocin

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Source	Industry/Products	Problem/Risk	Preventive Controls Suggested
Bryan et al., 1997	Processed foods	▪ Raw product/ingredient contaminated by pathogens ▪ Cross-contamination from raw ingredient of animal origin ▪ Bare-hand contact by food handler ▪ Handling by an intestinal carrier of enteric pathogens ▪ Inadequate cleaning of processing or preparation equipment ▪ Storage in contaminated environment	No specific controls suggested
Calicioglu et al., 2002	Soudjouk-style sausage	Natural fermentation may not eradicate *E. Coli* in the absence of controlled fermentation, post-fermentation cooking, and/or ambient-storage processing step	Use of a starter culture
Chmielewski and Frank, 2003	Processed foods	▪ Biofilm formation ▪ Infrequent cleaning of environmental surfaces, such as storage tank and pump exteriors, and walls and ceilings	▪ Biofilm development control via nutrient and water limitation, equipment design, and temperature control ▪ Use of chemical and physical force combination during cleaning ▪ Appropriate sanitizer selection ▪ Microbial load monitoring with plating of swabbing solution, contact plates, and the dipstick technique
Cliver, 1999	Fruits and vegetables Grains Dairy products Meat Poultry Fish	▪ Human errors in handling ▪ Pests and rodents ▪ Temperature abuse during handling	▪ Cold storage and appropriate selection of packaging for fruits and vegetables ▪ Pasteurization for milk ▪ Irradiation and dipping in a trisodium phosphate solution for poultry ▪ Proper handling and routine monitoring for toxins for fish
Cramer, 2003	Processed foods	▪ Microbiological (pathogens) hazards ▪ Physical (glass, metal shavings, wood) hazards ▪ Chemical (allergen cross contamination) hazards	▪ Adherence to the basic elements of sanitary design, including facility site selection, grounds and dust control, pest control, basic facility flow, plant materials, and equipment ▪ Cross-functional training of staff in sanitary facility and equipment design
Curiel, 2003	Processed foods	Increased probability of microbial contamination due to mild preservation technologies	Sanitary equipment design
Deibel, 2001	Not specified	Biofilm formation	▪ Effective cleaning and sanitation that combines physical and chemical methods ▪ Use of peroxide and peroxide-containing sanitizers instead of chlorine, iodophors, and most quaternary ammonium compounds

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Source	Industry/Products	Problem/Risk	Preventive Controls Suggested
Donnelly, 2002/2003	Smoked seafood RTE meat and poultry soft cheeses raw milk Mexican-style cheeses	▪ Listeria contamination due to niche environments ▪ Improper placement of drains	▪ Use of advanced chemical sanitizers to clean and sanitize surfaces ▪ Rotation of chemical sanitizers ▪ Employee-gowning protocols ▪ Easily cleanable boots ▪ Segregation of raw materials and food production areas ▪ Use of foot baths ▪ Foaming sanitizers and hand-washing systems ▪ Product reformulation ▪ Electronic pasteurization ▪ High-pressure processing (HPP)
Doyle E., 1999	Meat and poultry	Listeria	▪ Use of organic acids, other preservations, or bacteriocins in product formulation ▪ Application of additional process steps, such as thermal process, irradiation, high pressure, pulsed electric fields, electrolyzed oxidizing water, ultraviolet light, and ultrasound ▪ Use of modified atmosphere packaging (MAP)
Doyle, 2000	Foods of animal and plant origin	▪ Animals and animal manure used for foods are a leading source of food borne pathogens ▪ Imported foods	▪ Education of producers ▪ Implementation of HACCP systems at the point of production
Drew and Belluck, 1998	Apple juice	▪ Use of decayed apples possibly have been in contact with deer feces ▪ Inadequate quality control	▪ HACCP ▪ Pasteurization
Ennen, 2003	Processed foods	Not specified	▪ HACCP training and implementation of date/lot/batch coding, metal detection and x-ray machines ▪ Audit programs ▪ Process control and plant improvements training ▪ Locking of milk tankers for security ▪ Increased production line sampling and improved clean-out procedures ▪ Intervention processes for carcass beef, E. Coli test and hold programs ▪ HACCP/FDA inspections/AIB audits ▪ Research and development ▪ Personnel training
Erickson, 1995	Mayonnaise and mayonnaise dressing	▪ Use of unpasteurized eggs ▪ Wet environmental areas	▪ Use of pasteurized eggs ▪ GMPs ▪ Good hygienic practices

Table A-1: Summary of Literature Findings on Microbiological Safety Issues and Preventive Controls

Source	Industry/Products	Problem/Risk	Preventive Controls Suggested
ERS, 2001a	Meat and poultry	Not specified	▪ Animal or meat testing for pathogens, ▪ Knife sterilization and temperature, airflow, and other process controls ▪ Improved evisceration and hide, hair, and feather removal techniques ▪ Employee work methods and empowerment for food safety decisions ▪ Production line layouts that minimize cross-contamination ▪ Pathogen testing of equipment and plant environment ▪ Use of labor-saving equipment that reduces cross-contamination ▪ Rate at which workers' hands, tools, and equipment are sterilized ▪ Management strategies, like the Hazard Analysis and Critical Control Points (HACCP) system ▪ Steam pasteurization and/or vacuuming ▪ Hot water sprays ▪ Use of Chlorinated water and other sanitizers to disinfect product, work surfaces, and equipment ▪ Competitive exclusion (poultry) ▪ Automation of manual processes
ERS, 2001b	Meat and poultry	Pathogens	Irradiation
FDA/CFSAN, 2001a	Selected RTE foods	▪ Plant renovations ▪ Use of defective processing equipment ▪ Inadequate pasteurization	Maintenance of food safety controls and strengthening of existing controls
FDA/CFSAN, 2001b	Seafood	▪ Bacteria (sporeformers and nonsporeformers) ▪ Viruses due to poor hygienic practices ▪ Worms and protozoa	▪ Good personal hygiene ▪ Elimination of insufficiently treated sewage to fertilize crops ▪ Freezing (parasite control)
FDA/CFSAN, 2001c	Fresh and fresh-cut produce	▪ Manure and biosolids ▪ Water for agricultural uses ▪ Improper postharvest packing, cooling, and storage practices	▪ Temperature control ▪ Physical removal of microorganisms ▪ Use of effective GRAS cleaning agents ▪ Ozone treatment ▪ Irradiation ▪ Biocontrol
FDA/CFSAN, 1999a	Fruits and vegetables and juices	▪ Contamination of damaged/decayed sites on the rind of fruits that pathogens may infiltrate via insects and birds or immersion in cold contaminated water ▪ Equipment cross contamination during processing	No specific controls recommended in the study

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Source	**Industry/Products**	**Problem/Risk**	**Preventive Controls Suggested**
FDA/CFSAN, 1999b	Oranges	*Salmonella Enterica Hartford* and *E. Coli* O157:H7 can be internalized in the fruit at infiltration levels of 3 percent or higher	Refrigeration reduces the survivability of *E. Coli* but not of *S. Hartford*
FDA/CFSAN, 1999c	Fresh unpasteurized apple cider	▪ Contamination through direct/indirect contact with animal feces during growing and harvesting of apples ▪ Pathogen migration through the flower end or breaks in the apple skin	▪ Culling ▪ Initial washing ▪ Prompt processing or refrigerated holding ▪ Final culling, washing, and brushing ▪ A closed processing system ▪ Equipment sanitation ▪ Environmental sanitation ▪ Employee hygiene ▪ Implementation of HACCP ▪ Pasteurization ▪ UV treatment ▪ High pressure sterilization ▪ Electric resistance heating ▪ Aseptic packaging ▪ Ultrafiltration ▪ Pulsed electric field ▪ Electromagnetic fields ▪ Pulsed light ▪ Ozone treatment ▪ Hot water rinses ▪ Irradiation ▪ Freezing and thawing ▪ Redundant processing controls ▪ Use of sanitizer dips and sprays and preservatives ▪ Microbiological testing of products
Floyd, 1999	RTE foods and some microwaveable products	▪ Areas with standing water ▪ Drains and floors ▪ Dry-cleaned operations	▪ Testing of areas that have a potential to contaminate the processing/packaging areas or adjacent spaces ▪ Environmental testing ▪ Equipment testing to validate the cleaning process ▪ Monitoring of the effectiveness of clean-up and sanitizing procedures ▪ Validation of changes to cleaning procedures ▪ Swabbing of dry-cleaned operations areas ▪ Testing of packaging material and packaging area
Food Quality Magazine, 1997	Not specified	Inadequate sanitation	Automated handwashing stations with boot dips
Gagliardi et al., 2003	Melons	Contaminated wash water	Focusing on water quality as an important control point at the farm and at processing and packing facilities

Table A-1: Summary of Literature Findings on Microbiological Safety Issues and Preventive Controls

Source	Industry/Products	Problem/Risk	Preventive Controls Suggested
Gregerson, 2002	Processed foods	Not specified	▪ On-the-job training of employees ▪ Cross training of employees ▪ Bonus programs, including benefits packages (medical, dental) and good work conditions ▪ Routine preventive and/or predictive maintenance schedules ▪ Antimicrobial treatments ▪ Rapid microbial detection systems
The Hartford, 1999	Shell eggs	Not specified	▪ Voluntary quality assurance programs, including cleaning and disinfecting hen houses between flocks, strict rodent control, washing of eggs, refrigeration between transport and storage, biosecurity measures, mortality monitoring, use of salmonella-free chicks and pullets ▪ In-shell pasteurization ▪ Irradiation ▪ Spraying of hatched chickens with Preempt ▪ Implementing HACCP
Hegenbart, 1996	Dairy foods Fruits and vegetables Grains Fish and seafood	▪ Pathogenic bacteria ▪ Toxins and carcinogens ▪ Mycotoxins ▪ Parasites and viruses	▪ Sanitation of the milking facility (dairy) ▪ Cleaning of the cows' udders prior to milking (dairy) ▪ Thermostatic control of milk holding tanks (dairy) ▪ Frequent changing of the bedding materials in holding pens (poultry) ▪ Feed testing (poultry) ▪ Competitive exclusion (poultry) ▪ Use of herbicides and pesticides (plants) ▪ Adequate irrigation and pest protection (crops) ▪ Post harvest cooking and/or freezing (seafood)
Higgins, 2003	Food and beverages	Post-processing contamination	▪ In-package sterilization ▪ Steam vacuuming ▪ Organic acid sprays ▪ Washes and Rinses ▪ Thermal pasteurization ▪ Irradiation ▪ Ultra high pressure pasteurization ▪ Coating drains or equipment parts with antimicrobial agents ▪ Cleaning and sanitizing surfaces

Table A-1: Summary of Literature Findings on Microbiological Safety Issues and Preventive Controls

Source	Industry/Products	Problem/Risk	Preventive Controls Suggested
Higgins, 2002	Dairy products	▪ Language barriers among plant employees ▪ Ineffective employee training ▪ Poor hygienic practices among employees	▪ Bilingual training ▪ Picture- and symbol-based approach to training and instruction ▪ Keypad controls on hand sanitizers that enable the collection of data on handwashing practices of employees ▪ Sensor-equipped paper towel dispensers to replace hand cranks ▪ Contour mapping and/or spatial analysis to identify any infestation hot spots in the plant
Higgins, 2001	Processed foods	▪ Reactive maintenance ▪ Lack of integration between operations and maintenance ▪ Lack of integration among CMMS, condition-based monitoring, and enterprise asset management systems	▪ Institution of a workable maintenance plan where predictive maintenance is applied to the most critical assets ▪ Integration of CMMS, monitoring, and enterprise asset management systems
Hoffman et al., 2002	Raw and smoked fish	*L. monocytogenes* strains may persist in a plant for years. Thus, environmental contamination is separate from that of incoming raw materials.	Regular *L. monocytogenes* testing of drains and molecular subtyping of isolates obtained
Holah and Thorpe, 2002	Not specified	▪ Ovens designed to drain into high-risk areas ▪ Leakage of sumps under ovens into high-risk areas	▪ Separation of processing areas from non-processing areas and high-risk from low-risk areas ▪ Monitoring and controlling cleaning and disinfection programs to prevent biofilms ▪ Intensive periodic cleaning in addition to routine cleaning ▪ Use of multiple cleaning products for specific operations ▪ Monitoring the efficacy of cleaning and disinfecting agents ▪ Microbiological testing
Ilyukhin et al., 2001	All processed foods	Control system failures as a result of inadequate control system validation measures	Formal and comprehensive training and maintenance programs for manufacturing equipment and control system
Jahncke and Herman, 2001	Cold-smoked finfish	▪ Improper refrigeration controls ▪ *Listeria monocytogenes* and *C. botulinum* spores present on fish ▪ Cross-contamination with *L. monocytogenes* during slicing and cutting	▪ Properly storing fish so that their internal temperature is less than 40 degrees Fahrenheit ▪ Thawing frozen fish under sanitary conditions ▪ Temperature control of the brine solution during brining ▪ Removal of thick and large parts ▪ Strict adherence to SSOPs and GMPs
Keller et al., 2002	Apple cider	▪ Certain processing areas, such as apple mills and tubing for pomace, and juice transfer, may harbor contaminants even after cleaning and sanitation ▪ Use of poor quality ingredients ▪ Poor sanitation ▪ Reuse of uncleaned press cloths	No specific controls recommended in the study

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Source	Industry/Products	Problem/Risk	Preventive Controls Suggested
Kindle, 2001	Not specified	▪ Wood-covered door frames that corrode over time ▪ Doors that unnecessarily remain open	Doors made of corrosion-resistant material
Krysinki, 1992	Not specified	▪ Effectiveness of sanitizers depends upon the surface being cleaned; polyester/polyurethane is most difficult to sanitize ▪ Effectiveness of biofilm removal with cleaners depends on the surface being cleaned; polyester/polyurethane is most difficult to clean	▪ Clean surfaces prior to sanitization for complete biofilm removal ▪ Combine GMPs with HACCP
Kuhn, 1995	Not specified	▪ Inadequate hand washing practices ▪ Lack of cleaning validation	▪ Automated hand-washing machines ▪ ATP bioluminescence monitoring ▪ Portable sanitation equipment
Kuntz, 1992	Not specified	▪ Molds ▪ Yeast ▪ Viruses ▪ Bacteria	▪ Prevention of contamination by proper cleaning of manufacturing equipment, ▪ Removal of microorganisms by washing, trimming, centrifuging, and filtration ▪ Removal of oxygen by applying a vacuum, or the replacement of oxygen by gases, such as nitrogen or carbon dioxide ▪ High or low temperature treatments depending on the type of food product ▪ PH control ▪ Control of water activity levels via cooking, baking, or dehydration ▪ Use of preservatives or inhibitory substances that have Generally Recognized as Safe (GRAS) status ▪ Irradiation
Morris, 2000a	Processed foods	Not specified	▪ Routine preventive and/or predictive maintenance schedules ▪ HACCP ▪ Pay-for-skills programs where the responsibility goes to the workers ▪ On-line standard plate count (SPC) ▪ Automated batch control

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Source	Industry/Products	Problem/Risk	Preventive Controls Suggested
Morris, 2000b	Processed foods	▪ Weak prerequisite programs, including SSOPs, GMPs, QA programs, consumer complaint monitoring, environmental monitoring, vendor certification, and allergen management ▪ Half-way HACCP programs due to lack of upper-management commitment ▪ Release of product despite CCP violations ▪ Inclusions of quality components in HACCP that dilute its effectiveness ▪ Weak CCP validations and hazard analyses ▪ Inadequate/inefficient documentation ▪ Inadequate training ▪ Lack of continuous improvement	No specific controls recommended in the study
Mortimore, 2003	Not specified	▪ Wrong perception of the value and complexity of HACCP implementation ▪ Traditional and/or hierarchical organizational structure ▪ Lack of expertise in hazard analysis and risk evaluation ▪ Lack of motivation and failure to develop the right attitude and skills for system maintenance	▪ Education about food borne illness and trends ▪ Education on how HACCP is a minimal system that ensures maximum control ▪ Education on how HACCP can help reduce sanitation costs and down time, lengthen shelf life, improve efficiency, and reduce waste
Murphy et al., 2003	Fully-cooked vacuum-packed chicken breast meat	Existence of *Listeria monocytogenes*	▪ In-package steam pasteurization ▪ In-package hot water pasteurization
Neff, 1999	Frozen vegetables	Ineffectiveness of chlorine (widely used to decontaminate process water) under certain circumstances	▪ Peroxyacetic acid ▪ Ozone ▪ Ultraviolet radiation
NFPA, undated	RTE foods	*Listeria monocytogenes*	▪ Applying a validated listericidal process where appropriate, ▪ Purchasing from suppliers with a *Listeria* control program, ▪ Minimizing the potential for recontamination, ▪ Adopting new technologies as soon as they are available, and ▪ Implementing an environmental monitoring program for *Listeria* spp. to verify that the control program is effective. ▪ In-package pasteurization ▪ Ionizing radiation ▪ Product reformulation with *L. monocytogenes* inhibitors

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Source	Industry/Products	Problem/Risk	Preventive Controls Suggested
Paulson, 1996	Not specified	▪ Gloves with poor barrier characteristics ▪ Ineffective hand washing among employees ▪ Hand contact with contaminative surfaces, such as mucous, blood, soil, urine, or feces	▪ Washing hands prior to donning gloves ▪ Ongoing employee training and education ▪ Institution of a quality control program ▪ Environmental disinfection/sanitation program ▪ Restriction of tasks among employees to prevent cross contamination
Raloff, 1998	Pasteurized egg products Hot dogs Poultry summer sausage Meat products	*Listeria monocytogenes* and *Clostridium*	Addition of bacteriocins to the food product
Riordan et al., 2001	Fresh fruit	Internalization of microflora in the fruit, especially in those that have been dropped and/or damaged	▪ Exclude dropped or damaged fruit from those that are designated for the production of unpasteurized juice or for the fresh or fresh-cut market ▪ Locate orchards away from potential sources of contamination, such as pastures
Rushing and Fleming, 1999	Acidified foods	Not specified	Maintenance of an adequately low pH of 4.6 or below throughout the food
Senkel et al., 1999	Apple cider	▪ Lack of specific GMP, sanitation standard operating procedures, and sanitation monitoring records ▪ Lack of adherence to GMPs and HACCP	▪ Ensuring conformance to GMP and sanitation procedures ▪ Ensuring conformance to HACCP
Siddiqi, 2001	Not specified	Pathogen transmitting pests, such as rodents, roaches, and flies	▪ An integrated pest management program that relies on inspection, monitoring, establishing action threshold levels, and implementing first non-chemical and then chemical measures ▪ Communication and education ▪ Computer-aided monitoring ▪ Nonvolatile nonrepellant insecticide formulations
Snowdon and Cliver, 1996	Honey	▪ Yeasts and spore-forming bacteria ▪ Coliforms ▪ Cross-contamination ▪ Insanitary equipment and buildings	Routine microbiological testing, including standard plate counts, yeast counts, bacterial spore-former assays, and coliform counts
Sommers et al., 2002	Ham	Existence of *Listeria innocua*	▪ Vacuum-steam-vacuum technology ▪ Ionizing radiation
Stier, 2002	Not specified	▪ Construction projects ▪ Increases in production volume	Evaluation of how changes affect one's operation and taking steps to ensure that food safety is not compromised in the process
Stopforth et al., 2002	Fresh beef	Biofilms on equipment surfaces to which *Listeria monocytogenes* cells can attach and persist despite washing and sanitizing	Correct sanitizer selection as each sanitizer has an optimal working environment in which it is most effective

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Source	Industry/Products	Problem/Risk	Preventive Controls Suggested
Thimothe et al., 2002	Raw, whole, and processed crawfish	Presence of *Listeria monocytogenes* and *Listeria* ssp. in drains and some employee contact surfaces	▪ Heat treatment during processing ▪ Practices preventing post-processing contamination (not specified)
Thomas et al., 2002	Cooked potato products	*Bacillus* and *Clostridium*	Addition of nisin to the product formulation
Tilden et al., 2002	Dry fermented salami	Presence of *E. Coli* O1576:H7 on raw meat used in manufacturing salami	Not specified
Tompkin et al., 2002	RTE processed foods	▪ Product testing is insufficient to indicate the mode of contamination ▪ Errors in food handling ▪ Establishment of a pathogen in a niche which is impossible to reach and clean with normal cleaning and sanitizing procedures	▪ Environmental and equipment testing to detect niches ▪ Inclusion of sampling sites that are good indicators of control, such as food contact surfaces ▪ Weekly or more frequent sampling of the food processing environment ▪ Improvements in equipment design to make cleaning more effective and to minimize breakdowns and repairs ▪ Increased use of post-packaging pasteurization with irradiation, hot water, steam, and high pressure
USDA/FSIS, 2002	Beef	Cattle is an important reservoir for *E. Coli* O157:H7	▪ Post-slaughter antimicrobial decontamination methods, including spray-washing, steam-vacuuming, steam pasteurization, warm water wash, trimming, lactic acid decontamination ▪ Chilling and temperature control for finished product storage

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Source	Industry/Products	Problem/Risk	Preventive Controls Suggested
USDA/FSIS, 2001	Meat and poultry	▪ Food contact surface contamination between the cooking and packaging steps ▪ Cross contamination ▪ Reservoirs of *L. monocytogenes*, including floors and drains, standing water, ceilings and overhead pipes, refrigeration condensation units, recess or hollow material, air filters, and open bearings	▪ Dry cleaning ▪ Pre-rinsing equipment ▪ Foaming and scrubbing ▪ Rinsing ▪ Visual inspection of equipment ▪ Cleaning walls and floors ▪ Sanitizing ▪ Drying ▪ Environmental and contact surface testing to determine the effectiveness of cleaning and to identify potential sources of contamination ▪ Rotating sanitizers periodically ▪ Alternating between alkaline and acid-based detergents to avoid soapstone or hard water buildups and formation of biofilms ▪ Plant design to eliminate traffic flow between RTE and raw product areas ▪ Use of dehumidifiers and drip pans in RTE areas ▪ Smooth, sealed, and moisture-free ceilings and walls ▪ Filtered air supply ▪ Light fixtures that do not harbor dirt or moisture ▪ Environmental testing of non-food contact surfaces, food contact surface testing, and product testing ▪ Regular validation of test results by a third party
Walker et al., 2003	Not specified	Lack of hygiene knowledge among food handlers	Not specified
Young, 2003	Not specified	Equipment that is not designed to be cleaned with the help of automation	▪ Automated sanitation systems ▪ Transfer of sanitation duties from the third to second or first shifts and to better-trained employees ▪ Use of ozone (instead of chlorine) as disinfectant

Table A-2: Summary of Literature Findings on General Chemical Safety Issues and Preventive Controls

Source	Industry/Products	Problem/Risk	Preventive Controls Suggested
Bryan et al., 1997	All foods	▪ Natural toxins ▪ Spillage of chemicals ▪ Indiscriminate spraying of chemicals ▪ Misreading labels ▪ Adding too much of an approved ingredient ▪ Leaching of toxic containers or pipelines due to acidic foods	No specific controls recommended
FDA/CFSAN, 2001	All foods	Chemical hazards occur: ▪ Naturally (e.g., mycotoxins, allergens, and marine toxins) ▪ From intentionally added chemicals (e.g., preservatives, and nutritional and color additives) ▪ From unintentionally added chemicals (e.g., pesticides, veterinary drugs, toxic elements, and cleaning/sanitizing chemicals)	No specific controls recommended
Folks and Burson, 2001a	All foods	Raw materials may be contaminated with: ▪ Pesticides ▪ Antibiotics ▪ Hormones ▪ Toxins ▪ Fertilizers ▪ Fungicides ▪ Heavy metals ▪ PCBs During processing, contamination can occur with: ▪ Preservatives ▪ Flavor enhancers ▪ Color additives ▪ Peeling aids ▪ Defoaming agents ▪ Pesticides ▪ Cleaners/sanitizers	▪ Store chemicals separately from food and packaging materials ▪ Thoroughly rinse cleaning agents and sanitizers from equipment ▪ Only use USDA-approved chemicals ▪ Pest control should be performed by professionals ▪ Pest control residues in food should be controlled ▪ Inventory should be kept of chemicals, colorings, and additives ▪ Conduct audits of chemicals used ▪ Train employees adequately about chemical use ▪ Test product in-house for residues
Jahncke and Herman, 2001	Cold-smoked fish	▪ Temperature abuse of Scrombotoxin-susceptible fish	▪ Certification of proper time and temperature handling on vessel ▪ Sensory evaluation ▪ Analytical testing ▪ Refrigerated at 40 F or less ▪ Rapid cooling of the product after cold-smoking process

Table A-2: Summary of Literature Findings on General Chemical Safety Issues and Preventive Controls

Source	Industry/Products	Problem/Risk	Preventive Controls Suggested
Moulton, 1992	All food	▪ Pesticide residue	▪ Organic production systems ▪ Integrated pest management ▪ Low input sustainable agriculture (LISA) ▪ Development of safer chemicals ▪ Genetically-engineered, pest-resistant plants
Tybor et al., 1990	Various	▪ Metal poisoning from food handling equipment and utensils due to corrosion ▪ Pesticide spills ▪ Indiscriminate spraying of facilities with pesticide ▪ Improper storage or mistaken identity of pesticides ▪ Incomplete washing of produce ▪ Adding too much of intentional food additives ▪ Unintentional food additives	▪ Use equipment and utensils that do not corrode with citrus fruits, fruit drinks, fruit pie fillings, tomato products, sauerkraut, and carbonated beverages ▪ Store and secure pesticides away from food products ▪ Handle pesticides like poisons ▪ Avoid indiscriminate application of pesticides ▪ Use trained and certified personnel in application of pesticides ▪ Avoid use of empty cleaning chemical containers for food storage ▪ Properly train personnel about cleaning and sanitizing ▪ Use only approved food grade lubricants and greases ▪ Maintain chemicals in original containers ▪ Read and follow instructions on labels ▪ Keep inventory of chemicals in a secure, supervised area

Table A-3: Summary of Literature Findings on Allergen-related Chemical Safety Issues and Preventive Controls

Source	Industry/Products	Problem/Risk	Preventive Controls Suggested
CSPI, 2001	Processed foods	▪ Modification of product recipe without changing the label ▪ Not separating production runs ▪ Not cleaning machines properly between runs	▪ Cross-checking ingredients on labels ▪ Separate production runs ▪ Clean machinery properly
Deibel et al., 1997	Processed foods	▪ Raw material contamination ▪ Allergen contamination from products containing allergens run on same production line ▪ Improper use of rework ▪ Cross-contamination from maintenance tools ▪ Incorrect labeling or packaging ▪ Cross-contamination from conveyor belts ▪ Inadequate cleaning between allergen-containing product run and nonallergen-containing product runs ▪ Older equipment difficult to clean ▪ Lack of employee training	An allergen prevention plan that includes: ▪ A close working relationship with material suppliers ▪ On-site audits of material suppliers ▪ Allergen training for suppliers ▪ Longer run times that minimize changing products ▪ Scheduling the allergen-containing product at the end of the run ▪ Covering transport belts to prevent ingredients from falling ▪ Identifying and documenting rework ▪ Color coding maintenance tools or specifying proper cleaning procedures ▪ Verifying labels and packaging (e.g., with bar code scanners) ▪ Physical detachments or lockouts for equipment with high-contamination risk ▪ Enclosure of line crossover points ▪ Verification of cleaning between allergen and nonallergen runs ▪ ELISA tests ▪ Employee training
FDA/CFSAN, 2001d	Ice cream, bakery, and candy	▪ Omittance of raw ingredients that are potential allergens from label ▪ Failure of label review policies ▪ Contamination of product by utilization of rework ▪ Use of common utensils ▪ Allergen and nonallergen runs were not scheduled or sequenced ▪ No dedicated equipment for allergen runs ▪ Inadequate cleaning of lines (rinsing with water only or cleaning at end of day only) ▪ Lack of training in allergen control	▪ Effective label review policies ▪ Scheduling production of allergen-containing products at the end of production runs ▪ Proper use of rework ▪ Equipment and system design considerations ▪ Thorough cleaning of lines after running allergen-containing products ▪ Effective management of label inventory ▪ Control of ingredients from suppliers ▪ Training of employees in allergen control

Table A-3: Summary of Literature Findings on Allergen-related Chemical Safety Issues and Preventive Controls

Source	Industry/Products	Problem/Risk	Preventive Controls Suggested
FDA/CFSAN, 2001e	All foods	Food allergens enter food by means of: ▪ Misformulation ▪ Improper scheduling ▪ Use of rework ▪ Improper sanitation ▪ Cross-contamination	▪ Minimize equipment exposure to allergens ▪ Designate and label equipment for use with specific products ▪ Enclose equipment ▪ Avoid crossovers of production lines ▪ Add allergens near the end of a process ▪ Schedule longer run times ▪ Run nonallergen-containing products before allergen-containing products ▪ Produce allergen-containing products on a separate day than other products ▪ Adequate control on rework ▪ Discarding old labels and packaging materials ▪ Conduct label audits ▪ Appropriate sanitation ▪ Training on allergens and sanitation
FDA/CFSAN, 2001f	Fish and fisheries products	Food and color allergens in foods	▪ Declare the presence of an allergen ▪ Test for residue of an allergen ▪ Require supplier certification ▪ Review label of raw materials
Floyd, 2000	All foods	▪ Lack of product scheduling ▪ Lines are not separated ▪ Raw material contamination may be beyond a manufacturer's control ▪ Poor equipment design ▪ Lack of employee training	▪ Employee training ▪ Scheduling of production runs ▪ Separation of allergenic and nonallergenic products, with dedicated bins, scoops, and weighing buckets ▪ Staging areas (putting all ingredients for a specific batch on a pallet before processing) ▪ Line clearance after allergen processing ▪ Verification with test kits ▪ Design plant to avoid dust carryover ▪ Improved equipment design ▪ Add warning to label as last resort

Table A-3: Summary of Literature Findings on Allergen-related Chemical Safety Issues and Preventive Controls

Source	Industry/Products	Problem/Risk	Preventive Controls Suggested
Gregerson, 2003	All foods	▪ Poor sanitation ▪ Use of common utensils ▪ Reuse of baking parchments ▪ Use of table with surface nicks that caused cross-contamination ▪ Raw material contamination ▪ Lack of dedicated lines or allergenic product scheduling at end of day ▪ Lack of proper identification of materials	▪ Obtain full ingredient list from suppliers ▪ Investigate whether any allergenic processing aids/rework has been incorporated into the product ▪ Investigate possible product carryover from common equipment ▪ Replacement of non-functioning or non-characterizing allergens ▪ Allergenic products should be run on dedicated lines or scheduled at end of day ▪ Long run times for allergenic products to minimize product carryover ▪ Rework areas, equipment, and containers should be clearly identified through use of color tags, bar codes, etc. ▪ Equipment should be made of sanitation friendly material, like stainless steel ▪ ELISA tests
Higgins, 2000	All foods	▪ Inadequate washdown ▪ Too many changeovers, ▪ Scheduling allergen-containing products before non-allergen containing products ▪ Poor equipment design ▪ Products shipped in wrong package ▪ Lack of line separation	▪ Proper washdown techniques ▪ Longer production runs ▪ Scheduling allergen-containing products for the end of the day ▪ Sanitary equipment design ▪ UPC scanners to ensure correct packaging ▪ Add allergens at the end of the line ▪ Focus on 8 common allergens ▪ Validate allergen-control program with testing kits of in-process and finished foods

Table A-3: Summary of Literature Findings on Allergen-related Chemical Safety Issues and Preventive Controls

Source	Industry/Products	Problem/Risk	Preventive Controls Suggested
Minnesota Department of Agriculture, 2003	Processed foods	▪ Poor equipment design ▪ Crossover of conveyor lines ▪ Allergen addition point not isolated on line ▪ Re-feed systems are not dedicated ▪ Raw material contamination ▪ Product lines are not dedicated or allergenic products are not run last ▪ Inadequate sanitation ▪ Incorrect labeling or packaging ▪ Contaminated maintenance tools ▪ Lack of employee education	▪ HACCP ▪ Consider non-allergenic substitutes ▪ Add allergenic ingredients at end of process ▪ Sanitary equipment design ▪ Allergen addition point of line should be isolated ▪ Re-feed systems should be dedicated ▪ Product should be contained on line ▪ Eliminate crossover of conveyor lines ▪ Ensure suppliers have implemented and documented an allergen plan ▪ Products with allergens should be run at one time or at the end of a production run ▪ Adequate cleanup is required between runs ▪ All rework should be clearly labeled ▪ Labels should be verified ▪ Outdated packaging material should be removed from plant ▪ Sanitation practices should be validated using sight, bioluminescence, and ELISA tests ▪ Check maintenance tools for cross-contamination ▪ Employee training
Morris, 2002	All products	▪ Lack of dedicated lines or not adding allergenic product at end of process ▪ Crossover of conveyor lines ▪ Contaminated maintenance tools ▪ Too many changeovers ▪ Poor sanitation ▪ Lack of employee training	▪ Eliminate allergens if possible ▪ Add allergenic ingredient at end of process ▪ Dedicate production line to allergenic products ▪ Cover conveyors ▪ Seal off allergen addition points on line ▪ Color code maintenance tools ▪ Audits and documentation should be required of raw material suppliers ▪ Longer production runs with minimal changeovers for high-volume products ▪ When changeovers are necessary, products containing allergens can be scheduled last in the production cycle ▪ Discard old packaging ▪ ELISA tests ▪ HACCP ▪ Employee training

Table A-4: Summary of Literature Findings on Mycotoxin-related Chemical Safety Issues and Preventive Controls

Source	Industry/Products	Problem/Risk	Preventive Controls Suggested
Moss, 2002	Cereals, legumes, oilseeds, treenuts, milk, meat, coffee, cocoa, fruits, spices	▪ Insect damage ▪ Drought ▪ High water activity ▪ Mold growth	For preventing aflatoxin contamination: ▪ Preventing insect damage ▪ Alleviating drought stress ▪ Reducing water activity in product For preventing ochratoxin A contamination: ▪ Prevention of mold growth at every stage of production For preventing patulin contamination: ▪ Removal of moldy apples ▪ Treatment with charcoal or sulfur dioxide For preventing fumosin contamination: ▪ Breed cultivars resistant to insect damage and ear rot ▪ Biological control in the field
Bissessur et al., 2001	Apple juice	Production of patulin in apple juice	▪ Charcoal treatment ▪ Chemical preservation using sulfur dioxide ▪ Gamma irradiation ▪ Fermentation ▪ Trimming of fungus-infected apples ▪ Clarification methods (including pressing, centrifugation, fining, enzyme treatment, and filtration)
Boutrif, 1999	Tree nuts	▪ Drought ▪ Insect infestation ▪ Delayed harvesting ▪ Mechanical damage ▪ Moisture and heat during storage ▪ Immature kernels	▪ Timely harvesting ▪ Pesticides ▪ Minimize mechanical damage ▪ Electronic sorting to remove immature, damaged, or mold infested kernels ▪ Handpicking to remove immature, damaged, or mold infested kernels ▪ Chemical/heat inactivation of mycotoxins ▪ Proper storage to protect from moisture and heat
GASGA/CTA, 1997	Grains	▪ Insect damage ▪ Temperature stress ▪ High water activity	For field fungi: ▪ Protection from insect damage ▪ Protection from temperature stress For storage fungi: ▪ Dry grain as soon as feasible ▪ Store under modified atmospheric conditions ▪ Protect from damage and insects ▪ Sample for fungi

Table A-4: Summary of Literature Findings on Mycotoxin-related Chemical Safety Issues and Preventive Controls

Source	Industry/Products	Problem/Risk	Preventive Controls Suggested
Horne et al., 1989	Grains	▪ Droughts ▪ Temporary storage conditions ▪ High moisture storage conditions ▪ Immature or broken kernels	▪ Detect mycotoxin with black light ▪ ELISA tests ▪ Other screening programs ▪ Storage facilities with 13 percent moisture content ▪ Anhydrous ammonia treatment ▪ Shaking out immature or broken kernels
Jackson, et al, 2003	Apple cider	▪ Damaged fruit ▪ Dropped apples ▪ Washing inadequate for high levels of contamination	▪ Use tree-picked apples ▪ Cull apples ▪ Washing (not for high levels of contamination)
Park et al, 1999	Crops	▪ Insect damage ▪ Drought ▪ Lack of timely harvesting ▪ High moisture storage ▪ High temperature during storage ▪ Physical damage during processing	▪ Effective insect control ▪ Adequate irrigation schedules ▪ Timely harvesting ▪ Minimize mechanical damage during harvesting ▪ Removal of extraneous material ▪ Dry products to under 10 percent moisture ▪ Storage on dry, clean surface ▪ Clean up and separation of product ▪ Thermal inactivation of mycotoxins ▪ Chemical inactivation of mycotoxins ▪ Ammoniation ▪ Activated carbons and clays
Suttajit, 1989	Peanuts and corn	▪ High temperature ▪ High humidity ▪ Insect damage	▪ Drying to less than 9 percent moisture for peanut and less than 13.5 percent moisture for corn ▪ Maintenance of warehouse at low temperature ▪ Effective insect control ▪ Chemical treatment ▪ Handpicking ▪ Organic solvents ▪ Heating and cooking ▪ Ionizing radiation
USDA/ARS, 2002	Wheat, barley, peanuts, corn, cottonseed, tree nuts, and figs	▪ Aflatoxin and deoxynivalenol production ▪ High humidity and rainfall	▪ Future: gallic acid ▪ Humidity control

Table A-5: Summary of Literature Findings on Physical Safety Issues and Preventive Controls

Source	Industry/Products	Problem/Risk	Preventive Controls Suggested
Folks and Burson, 2001	All foods	Any extraneous object or foreign matter in food, sources include: ▪ raw materials ▪ poorly maintained equipment ▪ improper production procedures ▪ poor employee practices	▪ Raw material inspection and specification ▪ Vendor certification and letters of guarantee ▪ Metal detectors ▪ X-ray technology ▪ Effective pest control ▪ Preventative equipment maintenance ▪ Proper sanitation procedures ▪ Proper maintenance and calibration of detection equipment ▪ Appropriate handling of packaging material ▪ Proper shipping, receiving, and storage practices ▪ Tamper-proof or tamper-evident packaging ▪ Employee education ▪ Protecting light fixtures ▪ Controlling contact between pieces of machinery
Olson, 2002	All foods	Hard or sharp objects are food safety hazards, further classified into metallic and non-metallic objects. Sources include: ▪ Processing equipment ▪ Glass containers	▪ Periodic checks of metal equipment ▪ Metal detectors ▪ Passing product through separation equipment ▪ Visual examination of empty glass containers or containing transparent product ▪ Cleaning with water or compressed air and inverting glass containers ▪ Monitoring lines for glass breakage ▪ Proper adjustment of capping equipment ▪ X-ray systems
Stier, 2001	All foods	▪ Mechanical harvesters that collect more than just the product ▪ Improperly maintained equipment and lines ▪ Packages infested by rodents or insects ▪ Not shielding lights ▪ Lack of policies about glass breakage ▪ Struvite	▪ Plant audits that evaluate systems ▪ Destoners ▪ Magnets ▪ Screens ▪ Washers ▪ Proper equipment maintenance ▪ Tamper-proof packaging ▪ Insect/rodent control ▪ Employee education ▪ Glass breakage policies ▪ Scanners for glass ▪ Metal detectors

American Meat Institute (AMI). 2003. Sanitary Equipment Design. *AMI Fact Sheet.* March.

The AMI Equipment Design Task Force (EDTF) is comprised of representatives from ten meat and poultry processing companies. The EDTF has developed operational and equipment guidelines to minimize the spread of *Listeria* in meat processing plants. The EDTF has identified the critical nature of equipment design in reducing the risk of contamination of food products by *Listeria monocytogenes.* The 10 principles of sanitary design published by the EDTF include; (1) cleanability to a microbiological level, (2) made of compatible materials, (3) accessibility for inspection, maintenance, cleaning, and sanitation, (4) self-draining that does not allow for product or liquid collection, (5) hermetically-sealed hollow areas, (6) niche-free parts, (7) sanitary operational performance, (8) hygienic design of maintenance enclosures, (9) hygienic compatibility with other plant systems, and (10) validated cleaning and sanitizing protocols.
Keywords: meat processing, poultry processing,* Listeria*, equipment, cleaning, sanitation

BBC News. 2002. Finger Nails Hide Nasty Food Bugs. *BBC News*. Newssearch.bbc.co.uk/ 1/hi/health/2148501.stm. July 24.

The study, conducted by Michael Doyle and colleagues at the University of Georgia, indicates that cooks and chefs with long finger nails are more likely to pass on food bugs, such as *E. Coli*, to consumers. Further, long and artificial nails are a breeding ground for potentially harmful bacteria. Even after thorough washing and brushing, pathogens, such as *E. Coli*, can remain under finger nails and can be passed on to consumers.
Keywords:* E. Coli*, risk assessment

Beauchat, Larry R. and Jee-Hoon Ryu. 1997. Produce Handling and Processing Practices. *Emerging Infectious Diseases.* Vol. 3, No. 4.

Contamination of fresh produce with pathogens is not rare. Contamination can occur through contact with soil, raw or improperly composted manure, irrigation water containing untreated sewage, or contaminated wash water. Contact with mammals, reptiles, fowl, insects, unpasteurized products of animal origin, and contaminated surfaces (including human hands) are other potential points of contamination. Treatment of produce with chlorinated water reduces pathogenic and other microorganisms on fresh produce but does not eliminate them. Potential points of contamination need to be controlled in the field, during harvesting, processing and distribution, in retail markets, at food-service facilities, and at home.
Keywords: fresh produce, pathogens, handling, processing, controls

Bell, Chris and Alec Kyriakides. 2002a. Pathogenic *Escherichia Coli*. *In Foodborne Pathogens: Hazards, Risk Analysis and Control* edited by Clive de W. Blackburn and Peter J. McClure. Woodhead Publishing Limited and CRC Press LLC. Boca Raton, FL.

Controls that can reduce introduction of fecal pathogens into raw milk include effective hygiene and routine monitoring for pathogens. Meat contamination can be minimized by effective animal husbandry and proper hygiene. The inability to eliminate the pathogen has resulted in the introduction of steam pasteurization that decontaminates the surface of the meat while retaining the raw meat quality and appearance. Good agricultural practices (GAPs), microbiological testing, and chlorine washing can minimize contamination of produce. *E. Coli* can survive fermentation and therefore products made with this process should be examined with challenge studies to determine the critical control points that require effective control to minimize contamination. Washing efficacy is dependent on good contact between the

contaminant and the microbial agent and agitation assists in this process. Sprouting processes (alfalfa seeds) have also been implicated in *E. Coli* contamination. Testing is essential to achieve some control over this form of contamination. Segregation, effective cleaning, and disinfection are key to preventing post-process contamination.
Keywords: **E. Coli*****, good agricultural practices, risk analysis, pasteurization, controls, testing***

Bell, Chris and Alec Kyriakides. 2002b. *Salmonella*. In *Foodborne Pathogens: Hazards, Risk Analysis and Control* edited by Clive de W. Blackburn and Peter J. McClure. Woodhead Publishing Limited and CRC Press LLC. Boca Raton, FL.

Salmonella can be reduced by controlling the feed of food animals and poultry. Birds can also be vaccinated against infection. Animal husbandry practices also influence the spread of *Salmonella*. The same practices outlined for *E. Coli* can be used to prevent contamination of raw milk, raw meat and poultry, eggs, and produce.
Keywords: **Salmonella*****, controls, risk analysis, animal husbandry***

Bell, Chris and Alec Kyriakides. 2002c. *Listeria Monocytogenes*. In *Foodborne Pathogens: Hazards, Risk Analysis and Control* edited by Clive de W. Blackburn and Peter J. McClure. Woodhead Publishing Limited and CRC Press LLC. Boca Raton, FL.

L. monocytogenes is widespread in the environment and occurs in all raw food materials from time to time. The factors that contribute include raw material or product exposed to contamination, product manufactured with no processing stage to kill the organism, product with few or no preservatives, and product exposed to post-process contamination. The pathogen can grow at very low temperatures in foods. Control of *Listeria* is dependent on preventing contamination of or growth in raw materials, destroying or reducing it if present in raw materials, preventing recontamination in the factory by the environment, equipment or personnel. Monitoring and testing the product can be appropriate in some products, such as raw milk or smoked fish. Washing produce with chlorine also reduces contamination with *Listeria*. With respect to post-process contamination, there is probably no bacterial pathogen that exploits the food processing environment better than *Listeria*. The organisms are transferred either from the environment to the product or via product contact surfaces from aerosols or poor personnel handling practices. The best way to control *Listeria* is to eliminate it from the post-processing environment by segregating raw materials and processed materials and by practicing effective cleaning and sanitation. In addition to food product contact surfaces, the environment should be checked and cleaned, including reservoirs where *Listeria* can quickly grow to high levels. Cleaning practices themselves can also spread the organism and should be controlled. Routine monitoring of cleaning efficacy by means of sampling is also essential.
Keywords: **Listeria*****, risk analysis, controls, handling, post-processing, segregation, cleaning, sanitation***

Belluck, Pam and Christopher Drew. 1998. From a Farm in California to Outbreak of Food Poisoning in the East. *The New York Times*. January 5.

In July 1996, a small Californian lettuce company was identified as the source of an *E. Coli* O157:H7 bacteria outbreak. The organic farm did not use any chemicals to wash lettuce and operated in a barn next to a small cattle pen. The processing shed was completely open on one side, exposing the large stainless steel tub where the leaves of lettuce were washed before being mixed and shipped in three-pound boxes. Because the cattle were less than 100 feet away, cow feces could be blown into the shed by wind, washed in by rain, and tracked in on workers' boots, by animals or by the birds seen flying into the barn. Further,

dust from the trucks and cars driving in and out of the parking area and debris from the field were blown into the wash tank and wash area. In the wash tank, lettuce was swished around by employees, some of whom did not wear gloves, and who had no acceptable place to sanitize their hands. The company also had no quality control procedures in place. No chlorine, which can be used on organic foods to kill bacteria, was added to the wash water and no bacterial testing was done.
Keywords: fresh produce (lettuce), organic production,* E. Coli*, risk assessment

Berne, Steve. 1997. Simplifying Sanitation. *Prepared Foods*. March.

Sanitation and good employee hygiene practices are of high importance in ensuring food safety in a plant. Whether making sure employees keep good hygiene or checking the efficacy of sanitized equipment, keeping the procedure simple will more likely result in employees actually performing the required tasks. There are a number of systems on the market to ensure hygienic practices among employees and to check for the effectiveness of equipment sanitation. Meritech's CleanTech® system is a no-touch hand-washing system. The system provides a low-volume warm water wash followed by an antimicrobial solution spray. It also has a cycle counter so the frequency of hand and glove washing can be monitored. Color-coded cleaning materials are another way to simplify training and assure proper application. The colors and shapes ensure proper selection, ease identification and monitoring, simplify training and SSOP understanding. IDEXX has a new *Salmonella* detection system called Bind® which enables the manufacturer to test for the existence of *Salmonella* easily. There also are ATP bioluminescence cleaning validation systems for detection of food residue, yeast, mold, and bacteria on production surfaces.
Keywords: sanitation, employee hygiene, cleaning, equipment

Best, Daniel. 2000. Chicken or Egg – It's Safety First. *Food Processing*. April 2.

In-plant construction activities are a major culprit in food borne illness outbreaks in meat plants. Construction activity results in the dissipation of dust and, with it, microorganisms throughout a plant environment. Some of the control procedures include: avoidance of sample compositing during testing to detect contamination patterns, testing during operations to reflect true-life conditions in the plant, and nonrandomized testing. For egg producers, the control of *Salmonella* hinges on the adoption of multiple controls. Some of these controls include vaccination, competitive exclusion, and in-the-shell pasteurization. In the U.S., the United Egg Producers Association promotes the adoption of its Five Star program among its members that combines vaccination with sanitation, pest controls, washing and refrigeration controls.
***Keywords: meat processing, construction, risk assessment, controls, eggs, pasteurization,* Salmonella**

Bissessur, J., K. Permaul, and B. Odhav. 2001. Reduction of Patulin During Apple Juice Clarification. *Journal of Food Protection.* Vol. 64, No. 8.

Patulin is a mycotoxin produced by a number of molds involved in fruit spoilage. Various methods are currently used to reduce the levels of patulin in apple juice, including charcoal treatment, chemical preservation using sulfur dioxide, gamma irradiation, fermentation, and trimming of fungus-infected apples. Many of these processes are expensive and time-consuming. This study found that clarification methods, including pressing, centrifugation, fining, enzyme treatment, and filtration, were successful in reducing patulin levels in apple juice. However, the process resulted in high levels of patulin in the pressed pulp after filtration and centrifugation, and this could be harmful if used for animal feed.
Keywords: patulin, mycotoxin, juice, controls

Boutrif, Ezzeddine. 1999. Minimizing Mycotoxin Risks Using HACCP - The Cracker. *International Tree Nut Council.* September.

Pre-harvest drought, insect infestation and delayed harvesting are important external factors that contribute to mycotoxin formation. Some of these are difficult to control, but good agricultural practices (GAPs), such as timely harvesting and use of pesticides are controls that can reduce mycotoxin infestation. During harvest, mechanical damage should be minimized to prevent subsequent contamination. Crops should also be harvested in a timely manner to prevent mycotoxin formation due to high moisture levels. While prevention through pre-harvest management is best, should contamination persist or occur at a later time, processing and storage controls should be in place as well. Processing may involve removal of parts of the commodity, making it more susceptible to mold formation. Mycotoxins may be eliminated through physical separation or chemical/heat inactivation. Electronic sorting and handpicking can remove damaged, immature, or mold infested kernels and remove a significant amount of aflatoxins in shelled nuts. Proper storage is critical, as moisture, heat, and physical damage greatly increases the potential for mycotoxings to form. Stored products must be stored under dry and cool conditions that would prevent mold growth.
Keywords: mycotoxins, good agricultural practices, HACCP, risk assessment, controls, separation, storage

Brandt, Laura A. 1999. Hot Dog Days. *Prepared Foods*. August.

Listeria monocytogenes can grow at refrigerated temperatures if it gets on a product before packaging. Proper heating of hot dogs and meats can, however, reduce the risk of listeriosis, which affects mostly pregnant women, the elderly and the immunocompromised. Food manufacturers are trying to control such pathogens through revised plant procedures, packaging innovations, and by adding key ingredients. Some of the preservatives that are formulated into hot dogs and other processed meats to control the growth of pathogens include sodium nitrite, sodium lactate, sodium diacetate, polyphosphates, organic acids, smoke flavoring, and bacteriocins, such as nisin and pediocin.
Keywords: meat processing,* Listeria*, risk analysis, controls, preservatives

Bryan, Frank L., John J. Guzewich, and Ewen C.D. Todd. 1997. Surveillance of Foodborne Disease III. Summary and Presentation of Data on Vehicles and Contributory Factors; Their Value and Limitation. *Journal of Food Protection.* Vol. 60, No. 6: 701-714.

Factors that contribute to food borne illness outbreaks are identified in this paper, based on collection of food borne disease outbreak data from various sources. The contributory factors are situations or operations that allow contamination of foods and survival and/or proliferation of the etiologic agents in the foods. Contamination can occur with natural toxins, which are toxic elements found in animal or plant substances. Mushrooms are the most common example. Chemicals can enter foods through spillage or indiscriminate spraying. Misreading labels can also result in accidentally or incidentally adding poisonous substances to food. An approved ingredient can also be added in excessive quantities by accident, such as too much nitrite in cured meat or too much ginger powder in gingersnaps. Toxic substances in containers or pipelines can leach into food by contact with highly acidic foods. Raw ingredient can be contaminated or foods can be obtained from polluted sources. Foods that are not heated and are processed on or in equipment used previously with raw foods without proper cleaning can become cross-contaminated. Cross-contamination can also occur through workers who do not wash their hands, through cleaning aids, such as sponges that are not disinfected, or when raw foods touch or drip onto other foods. Inadequate hygiene on the part of food handlers and inadequate cleaning of equipment and utensils can also result in

contamination. Storage of dry foods in an environment where overhead drippage, back siphonage, airborne contamination, and access for insects and rodents are likely are also situations conducive to contamination. Other contributory factors are those that allow survival or fail to inactivate the contaminant, such as insufficient cooking time or temperature or inadequate acidification. Factors that allow proliferation of contaminants include inadequate refrigeration, insufficient acidification, inadequate fermentation, modified atmosphere packaging (MAP), and more. Data on these factors can suggest preventive measures to be adopted as practices.
Keywords: outbreaks, contributory factors, risk assessment, cleaning, cross-contamination

Calicioglu , Mehmet, Nancy G. Faith, Dennis R. Buege, and John B. Luchansky. 2002. Viability of *Escherichia coli* O157:H7 during Manufacturing and Storage of a Fermented, Semidry Soudjouk-Style Sausage. *Journal of Food Protection.* Vol. 65, No. 10: 1541-1544.

This study evaluated the manufacturing process for soudjouk-style sausage on the viability of *E. coli* O157:H7. Natural fermentation and drying processes were found to be less effective than the use of a starter culture in reducing levels of *E. coli* O157:H7. These results indicate that naturally fermented old-country-type sausage may allow the survival of *E. coli* O157:H7 in the absence of controlled fermentation, post-fermentation cooking, and/or an ambient-storage processing step. These results provide a framework for small-scale producers of “old-world” sausage to modify their current manufacturing processes to enhance product safety with regard to *E. coli* O157:H7.
Keywords: meat processing,* E. Coli*, risk assessment

Chmielewski, R.A.N. and J.F. Frank. 2003. Biofilm Formation and Control in Food Processing Facilities. *Comprehensive Reviews in Food Science and Food Safety*. Vol. 2: 22-32.

Microorganisms within biofilms are protected from sanitizers increasing the likelihood of survival and subsequent contamination of food. The type of food contact surface and topography play a significant role in the inability to decontaminate a surface. Abraded surfaces accumulate soil and are more difficult to clean than smooth surfaces. In most food processing plants, food contact surfaces are cleaned and sanitized daily. However, many environmental surfaces, such as storage tank and pump exteriors, walls, and ceilings, are cleaned infrequently. This infrequent cleaning provides the opportunity for biofilm formation if moisture is present. Nutrient and water limitation, equipment design, and temperature control are important in biofilm control. Cleaning can be accomplished by using chemicals or combination of chemical and physical force (water turbulence or scrubbing). Sanitizer selection should be based on whether or not a biofilm is likely to be present and the organic load likely associated with the biofilm. Manufacturing equipment must be fabricated using appropriate materials. Plants should monitor the microbial load on surfaces with plating of swabbing solution, contact plates, and the dipstick technique.
Keywords: food processing, biofilms, cleaning, sanitation, controls

Cliver, Dean O. 1999. *Eating Safely: Avoiding Foodborne Illness*. Prepared for the American Council on Science and Health. June.

Most food borne disease hazards are caused, not by additives or pesticides, but by microbes. Poor sanitation and preparation practices are more common in food-service operations and in the home than they are in food processing. The scientific knowledge necessary to eliminate pathogens at the farm level does not yet exist. The main sources of food contamination include human errors in handling, pests and rodents, and temperature abuse during handling. Prevention or minimization of human error is possible via the enforcement of good sanitary practices, such as thorough hand washing and glove wear for various

cases. There are additional considerations for different categories of foods, such as fruits and vegetables, grains, milk and dairy products, meat, poultry, fish, egg products, and other food products, such as ethnic foods, spices, honey, mayonnaise and dressings. Some of these include cold storage and appropriate selection of packaging for fruits and vegetables, pasteurization for milk, irradiation and dipping in a trisodium phosphate solution for poultry, and proper handling and routine monitoring for toxins for fish.
Keywords: food service, handling, sanitation, risk analysis, controls

Cramer, Michael M. 2003. Building the Self-cleaning Food Plant: Six Steps to Effective Sanitary Design for the Food Plant. *Food Safety Magazine*. February/March.

Incorporation of sanitary design into your facility can prevent development of microbiological niches, facilitate cleaning and sanitation, maintain or increase product shelf life and improve product safety by reducing potential of food borne illness, injury or recall. Food safety hazards that must be controlled include microbiological (pathogens), physical (glass, metal shavings, wood) and chemical (allergen cross contamination), while preventing product exposure to sources of filth (dust, rodent excrement). For cooked, ready-to-eat (RTE) products, the study recommends adhering to the following six basic elements of sanitary design:

- Facility site selection,
- Grounds and dust control – grading grounds for drainage and paving driveway and parking areas,
- Pest control – landscaping design to prevent pest harborage, adequate door seals, use of insect electrocuters,
- Basic facility flow – separate entrance for employees, isolation of lunchrooms, lockers, and restrooms, and use of captive shoes,
- Plant materials – use of easily cleanable materials for floors, walls, and ceilings, caulk-sealed seams, flush doorjambs, no sewage lines running over production or storage areas, and positive airflow in RTE areas, and
- Equipment – sanitary equipment design and third-party review of equipment design.

The study also recommends cross-functional training of staff in sanitary facility and equipment design to evaluate existing structure and plant equipment or to facilitate expansion and improvements. This can be accomplished through the use of available literature, or more effectively, through training courses offered by experts in the field.
Keywords: facility design, equipment, cleaning, sanitation, ready-to-eat, pest control, employee training

CSPI. 2001. *FDA Inspections Find Undisclosed Allergens in Processed Food*. April 3.

An unpublished government report found that many processed foods are contaminated with peanut or egg allergens but labeling does not disclose these substances. In an FDA survey of 85 small, medium, and large food plants, FDA and state inspectors found that only half of the firms were cross-checking ingredients on the labels with ingredients used in manufacturing the product. Some companies modified the product recipe without changing the label. Others were using contaminated equipment. In another study of cross-contamination issues, companies did not separate production runs or clean their machinery

properly. HACCP has been recommended by CSPI to ensure food does not become contaminated with allergens.
Keywords: allergens, labeling, risk analysis, cross-contamination, HACCP

Curiel, Roy. 2003. Building the Self-cleaning Food Plant: Hygienic Design of Equipment in Food Processing. *Food Safety Magazine*. February/March.

As a result of the development and application of increasingly mild preservation technologies, processed foods become more sensitive to microbial contamination, requiring greater control of the manufacturing process. One way to achieve this added control is to "build in" hygiene into the equipment used in the food manufacturing facility from the start. Selected criteria and basic requirements for a variety of hygienic equipment characteristics provide a fundamental overview of areas that can be addressed by food manufacturers. These include:

- *Materials of construction*. Product-contact materials must be inert to the product under operating conditions, as well as to detergents and antimicrobial chemicals (sanitizers) under conditions of use.

- *Surface roughness*. Product contact surfaces should be smooth enough to be easily cleanable. To achieve this quality of surface, polishing or other surface treatment may be required.

- *Crevices.* Crevices cannot be cleaned, and as such, will retain product residues that may effectively protect microorganisms against inactivation. The presence of slide bearings should be considered when writing procedures for cleaning and disinfection. These procedures may require instructions for both partial or total dismantling of equipment, or for increased cleaning times.

- *Screw threads*. The use of screw threads and bolts in the product area should be avoided. Where unavoidable, the crevices created should be sealed, at minimum.

- *Sharp corners*. Sharp corners in the product area should be avoided. Exceptions are constructions where the sharp corner is continually swept, such as in lobe pumps. Welds should not be made in corners, but on the flat surfaces, and must be smooth.

- *Dead areas.* There is a significantly reduced transfer of energy to the food residues (soil) in dead areas in process equipment that is placed outside of the main flow of cleaning liquids than there is to the soil in the main flow.

- *Drainability of equipment and process lines.* To make it possible to remove all chemicals from process equipment, the equipment must be designed to be self-drainable.

- *Top rims of equipment*. The design of the top rims of product-containing equipment must avoid ledges, where product can lodge and that are difficult to clean.

- *Mandoor covers*. Mandoor covers intended to protect the food products may accumulate dirt, which will enter the product in the vessel when the lid is opened. Policy should specify that no tank is opened during production unless absolutely necessary.

- *Shaft passages and seals*. Shaft passages and seals may leak product to the outside of the line. Microorganisms may then multiply in the product and grow back to the product side. Reciprocating shafts should be sealed by means of flexible diaphragms or bellows. To prevent the ingress of microorganisms in rotating shafts, double seals with microbiocidal barrier liquids should be used.

Keywords: equipment, facility design, cleaning, sanitation, controls

Deibel, Virginia. 2001. Biofilms. *Brain Wave Technologies: Thought for Food.* Vol. I. No. 1. May.

Chlorine, iodophors, and most quaternary ammonium compounds are ineffective against removing biofilms. The best method of controlling biofilms is to prevent their development in the manufacturing environment. Effective cleaning and sanitation, which combines physical and chemical methods within the program, will often prevent the accumulation of food product residues and bacterial cells on equipment surfaces. Cleaning by brushing, scrubbing, and scraping surfaces is often necessary because once a bacterial cell is released from the protection of a biofilm, it is much less resistant to subsequent sanitizers. Acid cleaners can be used to remove inorganic soil or material, such as rust, and using soft water for cleaning aids in the effectiveness of cleaning chemicals. Further, peroxide and peroxide containing sanitizers have been found to be highly effective in removal of biofilms.

Keywords: biofilms, cleaning, sanitation

Deibel, Kurt, Tom Trautman, Tom DeBoom, William H. Sveum, George Dunaif, Virginia N. Scott, and Dane T. Bernard. 1997. A Comprehensive Approach to Reducing the Risk of Allergens in Food. *Journal of Food Protection.* Vol. 60, No. 4: 436-441.

The control of food allergens in a food processing plant requires an allergen prevention plan that determines the potential sources of contaminating allergens and appropriate controls to prevent their introduction into products. A close working relationship with suppliers is important. The ingredient specification should warrant that the product is free of foreign material, including allergens. An on-site audit is recommended. The supplier should also provide a list of other products with allergens used on the processing line on which the manufacturer’s ingredient is produced. It may be necessary to raise awareness of suppliers through a training program. Longer run times that minimize changing products and scheduling the allergen-containing product at the end of a run reduce the chance of allergen contamination. Belts that run materials from one place to another should be covered to prevent ingredients from falling onto other belts and airflow should be considered. Rework must be clearly identified and documented. Maintenance tools should be color coded for specific areas or proper cleaning procedures should be specified. A process control check to verify that known allergens are listed on the ingredient label is essential. It is also important to verify that the food product is placed in the appropriately labeled package and that the appropriate label is placed on the product. Bar code scanners are sometimes used for this. The design of new lines or equipment must minimize the potential for human error. It is necessary to use physical detachments or lockouts of high-risk equipment if lines are used for both allergen and nonallergen containing foods. Crossover points should be enclosed. Verification of cleaning between allergen and non-allergen containing product runs is essential. Some equipment may need to be disassembled and manually cleaned. ELISA tests are being developed for allergens that could help verify the cleaning procedures, which is currently limited to visual inspection. A major problem is that older equipment may not be designed to verify visual cleaning. Employee training programs have proven to be one of the most effective tools for preventing inadvertent contamination with allergens.

Keywords: allergens, controls, prevention, suppliers, equipment, labeling, cleaning, employee training

Donnelly, Catherine W. 2002/2003. Inside Microbiology: Getting a Handle on Listeria. *Food Safety Magazine*. December 2002/January 2003.

Listeria is a very common pathogen that can be found almost anywhere in the environment. Some of the high risk foods for *Listeria* contamination include smoked seafood, ready-to-eat (RTE) meat and poultry products, soft cheeses, raw milk and Mexican-style cheeses, especially products not commercially prepared. The main control mechanism that the food industry has in place for protecting products like RTE meat and poultry from *Listeria* contamination is to clean and sanitize to eliminate the pathogen and then to conduct environmental testing and monitoring to verify that sanitation efforts have been successful. *Listeria* establishes niches in food processing plant environments and unless there is absolutely rigorously focused sanitation, it can persist for months or years within food plant environments. Further, most food processing plants in the U.S. were not designed with control of this pathogen in mind. For example, drains may have been placed in undesirable high-traffic floor areas where cross-contamination can easily occur. One of the responses to the *Listeria* crisis in the mid-1980s in the dairy industry was major plant redesign activities, including redesign of floors and drains so they could be effectively cleaned and sanitized and increased protection of the filling equipment from air contamination. There are many interventions used as part of the sanitation program in food companies, including the use of advanced chemical sanitizers to clean and sanitize surfaces and the rotation of those chemical sanitizers so that organisms do not have a chance to develop resistance over time, employee gowning protocols, easily cleanable boots, segregation of raw materials and food production areas, use of foot baths, foaming sanitizers and handwashing systems. Another intervention strategy involves making changes within the products themselves. Kraft Foods, for instance, has developed a potassium lactate and sodium diacetate preservative system that, when used in the formulation of products like hot dogs, creates a good chemical barrier to the growth of *Listeria.* Additional control technologies include electronic pasteurization, especially when done in the package, irradiation, other non-thermal processing intervention technologies, such as high pressure processing (HPP). Because the greatest risk of *Listeria* growth is through process contamination, however, it is very important that the intervention is applied in final package with any of these technologies.
Keywords: **Listeria*****, cleaning, sanitation, facility design, intervention, controls***

Doyle, Ellin M. 1999. Literature Survey of the Various Techniques Used in *Listeria* Intervention. *FRI Briefings*. Food Research Institute, University of Wisconsin. November.

Recalls, illnesses, and deaths associated with *Listeria* in food products have been reported over the past years. These incidences indicate that additional techniques may be needed for controlling *Listeria* in food processing plants and especially in those processing ready-to-eat (RTE) products. In response to the *Listeria* issue, on March 8, 1999, the Food Safety and Inspection Service (FSIS) of the USDA amended the Federal meat and poultry inspection regulations of certain RTE meat and poultry products. The new performance standards indicate the objective level of food safety performance that establishments must meet. The amended regulations, however, allow establishments to develop and implement processing procedures customized to the nature and volume of their production. The techniques covered in the literature survey include the use of organic acids, other preservatives, and bacteriocins in product formulations, application of additional process steps, such as thermal processes, irradiation, high pressure, pulsed electric field pasteurization, electrolyzed oxidizing water, ultraviolet light, and ultrasound, and use of modified atmosphere packaging (MAP) to suppress growth of food borne pathogens.
Keywords: ready-to-eat, **Listeria*****, intervention, regulation***

Doyle, Michael P. 2000. Food Safety Issues Arising at Food Production in a Global Market. *Journal of Agribusiness.* Vol. 18, No. 1: 129-133.

Food borne illness is a major public health concern in the United States, with an estimated 76 million cases occurring annually. More than 90 percent of food borne illnesses of known cause are of microbial origin. Animals used for foods and their manure are leading sources of food borne pathogens. Recent advances in the investigation of food borne outbreaks using genetic fingerprinting techniques enable epidemiologists to identify outbreaks and sources of implicated foods that heretofore were undetected. Tracebacks of outbreaks to the point of production place greater liability and responsibility on food producers. Implementation of Hazard Analysis Critical Control Point (HACCP) systems at the point of production is essential to increasing the safety of foods of animal and plant origin.
Keywords: outbreaks, tracking, HACCP

Drew, Christopher and Pam Belluck. 1998. Deadly Bacteria a New Threat to Fruit and Produce in U.S. *The New York Times*. January 4.

Several outbreaks of deadly bacteria in juice and produce have occurred in recent years. Lettuce from a small producer caused an outbreak of *E. Coli* O175:H7 in three states and sickened at least 61 people. The producer operated under unsanitary conditions, with the lettuce being washed and packaged less than a hundred feet from a cattle pen.

In mid-1995, orange juice served at Walt Disney World was contaminated with Salmonella. The contamination was believed to be caused by a toad that crawled onto the juice processing equipment. In response, the state of Florida drafted rules that required a two-step cleaning process of fruit, including an acid-based detergent and chlorine and that prevented the use of split or decayed fruit.

In late 1996, 70 people became sick after consuming Odwalla's fresh-squeezed apple juice. Odwalla's juice was not pasteurized at the time and thus required additional controls, like sorting out damaged fruit and washing the remaining fruit with sanitizers. Documents show, however, that in the weeks before the outbreak, Odwalla began relaxing its standards on accepting blemished fruit. Apples with defect rates of 25 to 30 percent were used, compared to the 5 percent that was normally acceptable to Odwalla in the past. Furthermore, a QA manager's recommendation to add a chlorine rinse to the acid rinse already being used was not implemented because another executive feared it would affect the taste of the juice (the brand of acid wash Odwalla was using was only able to kill all the *E. Coli* O175:H7 in 8 percent of lab tests and should not have been used without chlorine). Another quality assurance manager suggested testing for *Listeria monocytogenes* again, which had been found in orange and apple juice in 1995, but dropped the plan after resistance from upper management. In the outbreak case, the company was accused of using a batch of rotten apples, some with worms in them. Odwalla denied that the company took any such risks, but recognized that their safety systems failed. As a result of the outbreak, Odwalla hired safety consultants and voluntarily implemented a Hazard Analysis Critical Control Point (HACCP) plan. Odwalla also started using pasteurization to kill all pathogenic bacteria in its apple juice given that the skin gets mashed into the juice. Odwalla decided not to pasteurize orange juice given that the juice can be extracted without touching the rind.
Keywords: outbreaks, juice, fresh produce (apples),* E. Coli, *HACCP, pasteurization

Economic Research Service (ERS). 2001a. ***Industry Food Safety Actions: Conventional Practices and Technologies*****. U.S. Department of Agriculture, Economic Research Service. February 12. www.ers.usda.gov/briefing/IndustryFood Safety/convenprac/.**

In meat and poultry processing, the primary means of preventing the spread of pathogens is with conventional work practices, such as effective sanitation programs and the use of work programs that minimize opportunities for product contamination. Some of the most effective work practices as identified by food safety experts and plant managers include:

- Animal or meat testing for pathogens,
- Knife sterilization and temperature, airflow, and other process controls,
- Improved evisceration and hide, hair, and feather removal techniques,
- Employee work methods and empowerment for food safety decisions,
- Production line layouts that minimize cross-contamination,
- Pathogen testing of equipment and plant environment,
- Use of labor-saving equipment that reduces cross-contamination,
- Rate at which workers' hands, tools, and equipment are sterilized, and
- Management strategies, like the Hazard Analysis and Critical Control Points (HACCP) system.

These methods may be particularly important for small plants that may not have the resources to buy expensive technologies, such as automated carcass steam pasteurizers or irradiation equipment. Some of the conventional technologies available to meat and poultry processors include (1) steam pasteurization and/or vacuuming systems, (2) hot water sprays, (3) use of chlorinated water and other sanitizers to sanitize the product, work surfaces, and equipment, (4) competitive exclusion (applicable to poultry), and (5) automation of manual processes.
Keywords: meat processing, poultry processing, controls, sanitation, testing, work practices, HACCP

Economic Research Service (ERS). 2001b. ***Industry Food Safety Actions: Unconventional Technologies/Irradiation*****. U.S. Department of Agriculture, Economic Research Service. February 22. www.ers.usda.gov/briefing/IndustryFood Safety/unconventech/.**

Food processing firms, universities, and the USDA are conducting research on many new technologies to control pathogens. One of these technologies commonly accepted as a tool to kill all pathogens is irradiation. Depending on the type of food and radiation dosage, irradiation can be used to sterilize packaged food for storage at room temperature, eliminate or reduce pathogens, delay spoilage, control insect infestations, delay ripening, and inhibit sprouting. The capital costs of food irradiation equipment depend primarily on the irradiation source, food product, plant volume, and facility design. Further, there are substantial economies of scale involved in food irradiation with the cost per pound of irradiated meat decreasing by increases in annual volume.
Keywords: pathogens, irradiation, costs

Ennen, Steve. 2003. Safety Tops Concerns for Coming Year. *Food Processing*. January 1.

According to Food Processing's 2003 Manufacturing Survey, food safety is one of the most important issues facing the food industry today. The majority (64 percent) of respondents indicated that their companies have either implemented new food safety and sanitation initiatives or intend to do so. Among these respondents, 84 percent noted that their companies will address food safety with employee training. Another 73 percent indicated that their companies have plans to tweak or implement HACCP plans. Meanwhile, 60 percent of respondents said that their companies plan to improve pest control, while 55 percent said that plans to augment sanitation equipment are underway or completed. Among the many scientific safety initiatives cited were improved *E. Coli* testing, stronger biosecurity measures, audits, access restrictions, implementation of date/lot/batch coding, metal detection, and x-ray machines. Overall, 22 percent of respondents indicated that their companies had no plans to improve safety this year but no reasons were given for their decision.
Keywords: food safety initiatives, sanitation, employee training, HACCP, pest control

Erickson, J.P. 1995. An Assessment of Escherichia coli O157:H7 Contamination Risks in Commercial Mayonnaise From Pasteurized Eggs and Environmental Sources, and Behavior in Low-pH Dressings. *Journal of Food Protection*. Vol. 58, No. 10: 1059-1064. [only have abstract]

This study evaluated *E. Coli* contamination risk during commercial mayonnaise and mayonnaise dressing production, and *E. Coli* behavior in low-pH dressings. Two potential contamination sources, pasteurized liquid eggs and wet environmental areas were observed for 4 months in 3 processing plants. The study concluded that if plants use pasteurized eggs and GMPs, plants are unlikely to harbor *E. Coli*. Further, stringent hygienic practices by consumers and food-service workers can prevent microbial pathogen contamination during preparation, handling, and storage of mayonnaise-ingredient recipes, such as chilled perishable salads and salad-bar dressings.
Keywords: risk assessment,* E. Coli*, dressing (mayonnaise), eggs, employee hygiene

FDA/CFSAN. 2001a. *Draft Assessment of the Relative Risk to Public Health from Foodborne Listeria monocytogenes Among Selected Categories of Ready-to-Eat Foods*. January.

This risk assessment includes analysis of available scientific information and data in the development of exposure assessment and dose-response models to predict the public health impact of *Listeria monocytogenes* from 20 RTE food categories. Outbreaks often are due to a breakdown in food safety controls that have been put in place to prevent such occurrences. Outbreaks of listeriosis have been linked to plant renovations, use of defective processing equipment, and inadequate pasteurization. Maintenance of food safety controls and strengthening of existing controls is therefore paramount.
Keywords: ready-to-eat, risk assessment,* Listeria*, outbreaks, controls

FDA/CFSAN. 2001b. *Seafood HACCP Alliance HACCP Training Curriculum Manual: Hazards – Biological, Chemical, and Physical (Chapter 2)*. November.

Food safety hazards are typically categorized into three classes: biological, chemical, and physical. Biological hazards include harmful bacteria, viruses or parasites, such as *Salmonella*, Hepatitis A, and Trichinella. Chemical hazards include compounds that can cause illness or injury due to immediate or long-term exposure. Chemical hazards can be subdivided into naturally occurring chemicals (mycotoxins, allergens, marine toxins), intentionally added chemicals (preservatives, nutritional additives, color

additives), and unintentionally added chemicals (pesticides, veterinary drugs, toxic elements, food processing plant chemicals such as cleaners). Risks increase when chemicals are not controlled or the recommended treatment rates are exceeded. Physical hazards, on the other hand, include foreign objects in food that can cause harm when ingested, such as metal or glass fragments.
Keywords: seafood processing, HACCP, biological hazards, chemical hazards, physical hazards

FDA/CFSAN. 2001c. ***Analysis and Evaluation of Preventive Control Measures for the Control and Reduction/Elimination of Microbial Hazards on Fresh and Fresh-cut Produce*****. September 30.**

The extensive study identifies the various production practices that may influence the risk of contamination and exposure to pathogens in fresh and fresh-cut produce. Key areas of concern are practices related to prior land use, adjacent land use, field slope and drainage, soil properties, crop inputs and soil fertility management, water quality and use practices, equipment and container sanitation, worker hygiene and sanitary facilities, harvest implement and surface sanitation, pest and vermin control, effects of domesticated animal and wildlife on the crop itself or packing area, post-harvest water quality and use practices, post-harvest handling, transportation and distribution, and documentation and recordkeeping. Some of the control measures recommended include temperature control, physical removal of microorganisms, use of cleaning agents, such as chlorine, chlorine dioxide, bromine, iodine, quaternary ammonium compounds, acidic compounds with or without fatty acid surfactants, alkaline compounds, peracetic acid, hydrogen peroxide, and additional/new processing technologies, such as ozone, irradiation, and biocontrol.
Keywords: fresh produce, risk analysis, controls

FDA/CFSAN. 2001d. ***Food Allergen Partnership*****. January.**

In October of 1998, FDA formed a partnership with the Minnesota Department of Agriculture (MDA) and the Wisconsin Department of Agriculture, Trade, and Consumer Protection (WDATCP). One of the goals of the partnership was to obtain current information on allergen awareness and to provide training and information to the industry about effective control measures. Three ice cream, 31 bakery, and six candy manufacturers were inspected in Minnesota and 10 ice cream, 23 bakery, and 12 candy manufacturers were inspected in Wisconsin. A questionnaire was used to assess industry practices. Routine regular inspections were conducted. Six establishments in Minnesota and ten establishments in Wisconsin had written recall procedures addressing allergens. In 25 percent of establishments inspected, raw ingredients, such as nuts or artificial colors were omitted from the label. Of firms that felt they had adequate label review policies, 15 percent were found to have discrepancies. Further, 38 percent of the Minnesota and 64 percent of Wisconsin firms without label verification procedures were found to have undeclared allergen residues in their products. Most firms discarded labels after formulation changes. Further, of the 37 of 85 firms that utilized rework, roughly half had product that tested positive for allergens. Only four percent of establishments inspected used analytical testing to verify the effectiveness of cleaning and sanitation procedures. In Minnesota, 10 of the 40 firms had SSOPs that were proven effective and followed. In many establishments, common utensils were used in the production of allergen and nonallergen-containing products. Cross-contamination also occurred when baking sheets were reused without cleaning. Production was frequently not scheduled or sequenced for allergen control. Many firms also did not have dedicated equipment for allergen and nonallergen production. Cleaning of these lines was found to be inadequate, rinsing with water only or cleaning only at the end of the day. Further, only three of the 85 Minnesota and Wisconsin firms utilized personnel that were trained and dedicated to allergen control. When product was tested, a number of samples were positive for allergen residue. Many establishments changed operating procedures as a result of the findings from these inspections, including many sanitation changes. A number of establishments also did not make changes, however. In sum, industry awareness is

essential in the control of potential allergen residue risk. Possible controls include scheduling production of allergen-containing products at the end of manufacturing runs, appropriate labeling, proper use of rework, equipment and system design considerations, thorough cleaning of lines after running allergen-containing products, effective management of label inventories, control of ingredients from suppliers and training of employees.
Keywords: allergens, industry practices, labeling, testing, sanitation, cross-contamination, cleaning, employee training, controls

FDA/CFSAN. 2001e. *Food Allergen Monitoring*. January.

Food allergens can become part of food unintentionally by means of misformulation, improper scheduling, use of rework, improper sanitation, and cross-contamination. Controls include good manufacturing practices (GMPs), minimizing equipment exposure to the allergen, designating and labeling equipment for use with specific products, enclosing equipment and avoiding crossovers, adding allergens near the end of a process, scheduling longer run times, running non-allergen products before products with allergens, producing allergen products on a separate day from non-allergen products, color coding tools for allergen and non-allergen products, adequate controls on rework, discarding old labels and packaging materials, conducting label audits, appropriate sanitation, and training on allergens and proper sanitation.
Keywords: allergens, risk assessment, controls

FDA/CFSAN. 2001f. Chapter 19: Allergens, Food Intolerance Substances and Prohibited Food and Color Additives. *Fish and Fisheries Products Hazards and Controls Guidance.* June.

Some food and color additives can cause an allergic-type reaction in consumers. Sulfiting agents and FD&C Yellow #5 are additives used on fish and fisheries products that can cause such reactions. A number of foods also contain allergenic proteins. Possible preventive measures include declaring the presence of the allergen, testing for residue, requiring supplier certification that the product is allergen free, and reviewing labeling of raw materials.
Keywords: allergens, prevention, testing, labeling

FDA/CFSAN. 1999a. *Potential for Infiltration, Survival, and Growth of Human Pathogens within Fruits and Vegetables*. November.

Water, insects, and birds may serve as vectors resulting in contamination of damaged or decayed sites on the rind of fruits and vegetables. Under certain conditions, pathogens can infiltrate and become internalized in the fruit or vegetable. Fruit can also become contaminated if immersed in cold, contaminated water or if vulnerable external points of fruit are immersed in contaminated water. Equipment may also cross contaminate both fresh apple and orange juice during processing. Despite their natural acidity, pathogens are able to survive in these fruit juices. Thus, sanitation is extremely important in juice processing.
Keywords: fresh produce, risk analysis, juice, sanitation

FDA/CFSAN. 1999b. *Preliminary Studies on the Potential for Infiltration, Growth, and Survival of Salmonella enterica Hartford and Escherichia coli O157:H7 Within Oranges*. November.

Study indicated that infiltration of pathogens into oranges can occur. This study found that oranges can internalize pathogen at an uptake frequency of 3 percent. Observed infiltration levels may be conservative because intact fruit was used as well as a decontamination step. Cold storage reduced survivability of *E. Coli* but not of *S. Hartford*. These findings indicate that refrigeration cannot be used to ensure reduction of microbial pathogens. Further study is required to determine factors that lead to contamination and infiltration, with respect to cultivation, harvesting, transport, storage, and processing.
Keywords: fresh produce (oranges),* E. Coli, Salmonella*, cold storage

FDA/CFSAN. 1999c. *Report of 1997 Inspections of Fresh, Unpasteurized Apple Cider Manufacturers*. January.

Contamination of apple cider likely occurs during the growing and harvesting phase, through direct or indirect contact with animal feces. Washing apples may reduce surface contamination, but studies also report pathogens can migrate into the tissue of the apple through the flower end or breaks in the skin of the apple. Best practices include culling; initial washing; prompt processing or refrigerated holding; final culling, washing, and brushing; a closed processing system; equipment sanitation; environmental sanitation; and employee hygiene. Applying these best practices does not guarantee pathogen-free cider, but when applied along with HACCP, will substantially reduce the likelihood of contamination. Other possible control methods include pasteurization, UV treatment, high pressure sterilization, electric resistance heating, aseptic packaging, ultrafiltration, pulsed electric field, electromagnetic fields, pulsed light, ozone treatment, hot water rinses, irradiation, and freezing and thawing. Studies are needed to assess the effectiveness of some of these treatments and others (such as pasteurization) have been proven effective. Redundant processing controls, such as duplicating culling and washing/brushing steps at several points during the chain and use of sanitizer dips and sprays and preservatives, have also proven effective in other segments of the food industry. However, the inspection indicated that these practices are largely absent in the cider industry. Microbiological testing of products and the environment would also be helpful in assessing effectiveness of the controls in place.
Keywords: cider, fresh produce (apples), best practices, HACCP, controls, pasteurization, testing

Floyd, Bruce M. 2000. Battling Allergen Contamination. *Food Product Design.* December.

Companies must review their products to determine whether it contains any of the known 160 allergens. The people reviewing the products must receive training to recognize problematic families of foods. Other controls include scheduling, separation of products, staging areas, line clearance, and verification. Nonallergenic products should be scheduled first, preceded by a thorough cleaning of the line. Allergenic materials and nonallergenic materials should be stored separately, with dedicated bins, scoops and weighing buckets. Dust control is also essential and required by GMPs. Staging (putting all of the ingredients for a specific batch on a pallet prior to taking them to the processing area) will also eliminate errors before they occur. Removing all the ingredients from the weighing and production areas of a line and checking for cleanliness are also helpful in avoiding contamination. Test kits are also available that can detect the presence of peanut, egg, and milk at very low levels. These kits have to be applied by a technically experienced person who will need additional training. However, random, inadvertent contamination will be difficult to detect with testing. A good system builds preventative efforts into earlier components of the production process. Unavoidable contamination can occur if it is impossible to verify that all allergen residue has been removed from equipment or if plant design prevents separation of lines, increasing the likelihood of dust carryover. Furthermore, contamination of raw materials may be

beyond a manufacturer's control. In these cases, companies may need to redesign the plant or add warnings to the label, although these should be a last resort since they eliminate potential customers. Allergen contamination prevention boils down to improved equipment design, plant layout, material handling within the plant, supplier control and verification, and employee training. If allergen contamination still cannot be avoided, warnings should be put on the label.
Keywords: allergens, product review, prevention, controls, separation, facility design, equipment, employee training, handling, labeling

Floyd, Bruce M. 1999. Testing for Foodborne Pathogens. *Food Product Design.* July.

The article addresses pathogen-testing procedures for products that are minimally cooked by the consumer, including all RTE products, as well as microwaveable products that may not receive sufficient heating to kill the bacteria in question. Pathogen testing involves environmental testing, equipment swabbing and product testing of raw materials and finished product. If the product is not cooked in its packaging material, packaging should be tested as well. The quantity and type of testing depends on the product. GMPs must be in place and have been validated before designing a testing program. Traffic patterns need to be examined and environmental testing should occur in areas that have the potential to contaminate processing and packaging areas and their surrounding space. The particular organisms tested for will be those that are a problem in the given industry. Processes without a cook step and products that the consumer minimally processes, have a much greater need for testing on the raw material side. Under such a testing program, breaches will be detected before they reach crisis proportions.
Keywords: pathogens, testing, packaging, good manufacturing practices

Folks, Heather and Dennis Burson. 2001a. *Food Safety: Chemical Hazards*. University of Nebraska Cooperative Extension.

Raw materials can be contaminated with pesticides, antibiotics, hormones, toxins, fertilizers, fungicides, heavy metals, and PCBs. During processing, contamination can occur with food additives, preservatives like nitrite, flavor enhancers, color additives, peeling aids, and defoaming agents. Lubricants, paints, and coatings from buildings and equipment can also contaminate food. Further, pesticides, cleaners, and sanitizers can contaminate products. Chemical hazards can be controlled by storing them separately from food and packaging materials. Cleaning agents and sanitizers should be thoroughly rinsed from equipment during cleanup. Only USDA-approved chemicals should be used. Pest control should be performed by professionals and chemical residues in incoming food products should be controlled. An inventory should be kept of all chemicals, colorings, and additives. Audits should be conducted of chemicals used, employees should be trained adequately, and in-house testing of product should be conducted.
Keywords: chemical hazards, risk assessment, controls, separation, cleaning, pest control

Folks, Heather and Dennis Burson. 2001b. *Food Safety: Physical Hazards*. University of Nebraska Cooperative Extension.

A physical hazard is any extraneous object or foreign matter in a food item, which can cause illness or injury to a person consuming the product. Sources for such contaminants include raw materials, badly maintained equipment, improper production procedures, and poor employee practices. Controls include raw material inspection and specification, vendor certification and letters of guarantee, metal detectors, x-ray technology, effective pest control, preventative equipment maintenance, proper sanitation procedures, proper maintenance and calibration of detection equipment, appropriate handling of packaging material, proper shipping, receiving and storage practices, tamper-proof or tamper-evident packaging, and

employee education. Less obvious measures, such as protected lighting fixtures and controlling contact between pieces of machinery, should also be considered.
Keywords: physical hazards, risk assessment, controls

Food Quality Magazine. 1997. Did You Wash Your Hands? *Food Quality Magazine*. March.

Good sanitation is one of the most important aspect of working in a food processing plant. To ensure good sanitation, Haagen-Dazs has installed automatic washing systems at various locations in its processing area. The system is claimed to be 60 percent more effective in removing pathogenic bacteria from hands than manual hand washing. New versions of the automatic handwashing system also incorporate a boot dip for washing boots and an air curtain for drying hands.
Keywords: sanitation, cleaning, employee hygiene

Gagliardi, J.V., P.D. Millner, G. Lester, and D. Ingram. 2003. On-Farm and Postharvest Processing Sources of Bacterial Contamination to Melon Rinds. *Journal of Food Protection.* Vol. 66, No. 1: 82-87.

This study assessed the sources and extent of melon rind contamination in production fields and at processing and packing facilities. In the spring of 1999, cantaloupe sampled from two sites in the Rio Grande River Valley showed that postharvest-processed melon rinds often had greater plate counts of bacterial contaminants than field-fresh melons. Sources of coliforms and enterococci were at high levels in melon production soils, especially in furrows that were flood irrigated, in standing water at one field, and in irrigation water at both sites. At one processing facility, wash water pumped from the Rio Grande River may not have been sufficiently disinfected prior to use. Because soil, irrigation water, and process water were potential sources of bacterial contamination, monitoring and management on-farm and at processing and packing facilities should focus on water quality as an important control point for growers and packers to reduce bacterial contamination on melon rinds.
Keywords: fresh produce (melons), production, processing, risk analysis, water quality

GASGA/CTA. 1997. Mycotoxins in Grains. *Technical Leaflet*. No. 3. June.

There are five types of mycotoxins that occur often in food: deoxynivalenol, zearalenone, ochratoxin, fumonism, and aflatotoxin. There are those that invade before harvest, called field fungi, and those that occur after harvest, called storage fungi. The primary factors influencing the growth of field fungi are insect damage and temperature stress. For storage fungi, these are moisture content and temperature. To prevent growth in stored grain, the grain should be dried as soon as feasible. Storage under modified atmosphere conditions is desirable. The grain should be protected from damage and insects. Under storage, the grain can be sampled for fungi. [Note: Article is written in an international tone and thus, may be less applicable to U.S. operations.]
Keywords: mycotoxins, fungi, prevention, grains, storage

Gregerson, John. 2003. Plain Talk About Allergen Management. *Food Processing.* January 29.

Manufacturers are sometimes using a “may contain” statement on labeling that critics argue is regarded as a substitute for GMPs. Problems have been uncovered by FDA inspections that include conveyors handling both allergen and non-allergen containing products which were only washed once a year, use of common utensils with both types of products and reusage of baking parchments. Another case included an

ideal operation in terms of best practices, with the exception that a table contained surface knicks that caused cross-contamination. Many processors have begun to include allergens as part of their HACCP plan. Manufacturers should obtain full ingredient lists from their suppliers as well as investigate whether any allergenic processing aids or rework have been incorporated into the product, or whether product carryover from common equipment might have occurred. During product development, manufacturers should consider whether any non-functional or non-characterizing allergens can be replaced. Allergenic and non-allergenic runs should be done on dedicated lines, or otherwise scheduled at the end of the day and followed by a complete clean up. Allergens should be made in successive batches and runs should be longer to further minimize potential carryover. Rework areas, equipment and containers should be clearly identified, as well as the rework itself, through use of color tags, containers, plastic liners or bar coding. Equipment should be made of sanitation-friendly material, like stainless steel. ELISA tests can also be conducted.
Keywords: allergens, labeling, equipment, sanitation, HACCP

Gregerson, John. 2002. Third Annual Best Manufacturing Practices Survey. *Food Engineering.* February.

Food Engineering conducts an annual survey of best manufacturing practices in the food industry by interviewing a panel consisting of more than 400 food manufacturing professionals in top management, production management, engineering, quality control, packaging, and purchasing across every segment of the food industry. More than 80 percent of survey respondents work at plants with 249 employees or less. When asked about maintenance, 25 percent of respondents said they will run equipment until it breaks, while nearly 56 percent indicated that their plant maintains routine preventive maintenance schedules. Only 2.6 percent are employed in plants where condition monitoring tools are used and 8.5 percent have a predictive maintenance program. Employee training and HACCP programs continue to dominate efforts to improve food safety. Anti-microbial and rapid microbial detection systems are not as prevalent but 53 percent of respondents who use them rate them as very useful, compared to 40 percent of plants that use HACCP (either voluntarily or as mandated). Only 2 percent of respondents involved in voluntary HACCP programs rated them as not useful, compared to 14 percent involved in government-mandated HACCP programs. Employee training rated lowest among all food safety measures implemented. About one-third of those whose plants emphasized employee training in food safety rated it as “very useful.” Half of the plants that added sanitary equipment rated their results as very useful, compared to 41 percent whose plants improved employee training to improve sanitation.
Keywords: best practices, HACCP, employee training, equipment, maintenance, sanitation

The Hartford. 1999. Food Processing: *Salmonella. The Hartford Loss Control Department Technical Information Paper Series.*

A number of states, along with the United Egg Producers, have established voluntary quality assurance programs for egg producers. Participants agree to follow certain practices, including cleaning and disinfecting hen houses between flocks, adopting strict rodent control measures, washing eggs properly, refrigerating eggs between transport and storage, putting in place biosecurity measures, monitoring mortality of chickens, using salmonella-free chicks and pullets. Newer technologies are currently being explored, including in-shell pasteurization, irradiation, spraying newly hatched chickens with Preempt (a biotechnology product, approved by FDA, that contain bacteria that reduce Salmonella colonization of chicks’ intestines). The risk management control that can have the greatest effect in controlling *Salmonella* is the implementation of HACCP at all levels of food processing.
Keywords: eggs,* Salmonella*, animal husbandry, controls, HACCP

Hegenbart, Scott. 1996. Reinforcing the Links in the Food Safety Chain. *Food Product Design*. March.

In 1989, the Council for Agricultural Science and Technology (CAST), Ames, IA, created a task force to determine the state of knowledge about U.S. food borne disease risks. The task force's findings were released in a 1994 report entitled "Food Borne Pathogens: Risks and Consequences." Among the report findings are that the application of Hazard Analysis Critical Control Point (HACCP) systems can reduce the likelihood of foodborne illness. By designing hurdles along the entire length of this chain, the reduction of incidence and prevention of contamination would contribute to the overall safety. Pathogenic bacteria are usually the first targets of any food safety discussion because they are behind 90 percent of all food safety outbreaks. In dairy farming, the sanitation of the milking facility, cleaning of the cows' udders prior to milking, and careful thermostatic control of milk holding tanks are among the contributors to microbial control. Keeping *Salmonella* in check in poultry involves controls, such as more frequent changing of the bedding materials in holding pens, testing of feed, and competitive exclusion. Fruits and vegetables contain naturally occurring toxins most of which are destroyed or inactivated by processing and cooking. Because consumers are eating more fresh vegetables raw, however, it becomes important to control/minimize naturally occurring toxins. Eliminating the stress through the use of herbicides, pesticides, etc., can help reduce the natural toxins a plant produces. Controlling weeds is also critical because they may contain toxins and they could be harvested along with the crop. Mycotoxins that are produced by certain types of mold also pose a public health risk. Thus, controlling mold growth early in the food chain is critical since many mycotoxins are stable to the heat of subsequent processing. Fields must be given adequate moisture (through irrigation) and pest protection because drought and blight leave plants more susceptible to mold. Preliminary research is further revealing that specific soil conditions may reduce the plant's tendency toward mold growth. Fish and seafood commonly contain parasites. Because these foods are still primarily harvested rather than farmed, less control over the source is possible. Instead, more attention is given to post-harvest seafood handling because most parasites can be destroyed by processing/cooking heat and by freezing. Viruses also are readily destroyed by heat. The ones of greatest concern are Hepatitis A and Norwalk virus, which do not enter the food chain at this early stage and are usually the result of contamination by handlers. In the early links of the food chain, most viral food safety risks come from seafood.
Keywords: food chain, pathogens, risk analysis, HACCP, controls, good agricultural practices

Higgins, Kevin T. 2003. Food Safety: Say Goodbye to the Burn. *Food Engineering.* January.

Food and beverage processors have to determine which food safety initiatives give them the greatest return on investment. In-package sterilization is the solution to post-processing contamination associated with *Listeria* and is slowly gaining more acceptance in terms of irradiation of meat. Brawley Beef in California employs multiple food safety interventions, including steam vacuuming, organic acid sprays, washes and rinses, thermal pasteurization, and irradiation. Ultra high pressure pasteurization can also be applied in package, as is done by Avomex, Inc. Coating drains or equipment parts with antimicrobials are other applications that help keep facilities clean and safe, although they do not eliminate the need for cleaning and sanitizing surfaces. Given that the economic payoff of these investments is not clear, processors have to do a qualitative assessment of the technologies available to help them meet their food-safety objectives.
Keywords: food processing, post-processing, packaging, pasteurization, cleaning, sanitation, costs

Higgins, Kevin T. 2002. The Culture of Clean. *Dairy Foods.* November.

The key to keeping food plants safe is to develop the right strategies to make sure that sanitation standards are met. Effective training is essential and language may be a barrier. Bilingual signage manuals and instructional manuals can fall short when multiple languages are spoken. A picture and symbol based approach can be an affordable and effective solution. Experts can be helpful in motivating employees to comply with fundamental sanitation principles. Various aids, like keypad controls on hand sanitizers and sensor-equipped paper towels are also available. Contour mapping and spatial analysis can be used to proactively manage pest control. Overall, numerous technologies are available to sanitize a plant, but they are only effective if supported by plant employees.
Keywords: sanitation, employee hygiene, employee training

Higgins, Kevin T. 2001. Are Maintenance Needs Predictable? *Food Engineering*. May.

Predictive maintenance is scarce among food processors. Further, firms, who have reportedly adopted predictive maintenance, typically monitor some critical equipment while continuing preventive schedules and reactive maintenance on less important assets. A survey by Entek IRD suggests that only 5 percent of plant maintenance is predictive in nature. Another 25 percent is preventive and at least half of that work is unnecessary. Most of the rest is corrective despite the fact that it costs more than three times as much as predictive steps would have cost. In a food processing facility, the key to a workable maintenance plan is to prioritize the assets and to apply predictive maintenance to the most critical units. It is also important to integrate the control systems at a plant for predictive maintenance to work.
Keywords: food processing, maintenance, equipment, costs

Higgins, Kevin T. 2000. A Practical Approach to Allergen Control. *Food Engineering.* July.

Food processors have made a lot of progress on the issue of allergens, but a lot of work remains to be done. Good manufacturing practices (GMPs), HACCP, and sanitation are at the heart of any allergen control program. Wash-down techniques may need adjustment to ensure that sanitarians are removing allergen proteins as well as pathogens from equipment surfaces. Longer production runs to minimize changeovers and scheduling allergen-containing products on a line at the end of the day are also good control strategies. Thermal treatment is ineffective in ridding equipment of proteins that are the basis of food allergens. Sanitary equipment design is also very helpful to minimize the presence of allergens. UPC scanners can minimize the chance that allergen-containing products get shipped in the wrong package. Separation of lines will prevent cross-contamination. Adding allergens at the end of the line also simplifies cleanup. One of the problems is that any food that has a protein has the potential to be allergenic, but a manufacturer cannot control for all. Currently, the focus is on the eight most common allergens. There is also a lack of consensus on the acceptable trace levels of an allergen. Testing kits of in-process and finished foods and of equipment will help manufacturers validate their allergen-control programs.
Keywords: food processing, allergens, good manufacturing practices, separation, HACCP, sanitation, controls

Hoffman, Adam D. , Kenneth L. Gall, Dawn M. Norton, Martin Wiedmann. 2002. *Listeria monocytogenes* Contamination Patterns for the Smoked Fish Processing Environment and for Raw Fish. *Journal of Food Protection.* Vol. 66, No. 11: 52-60.

Environmental samples and raw fish from two smoked fish processing facilities were screened for *L. monocytogenes*, and all isolates were subtyped by automated ribotyping to examine the relationship between *L. monocytogenes* contamination from raw materials and that from environmental sites. Results indicate a disparity between the subtypes found on raw fish and those found in the processing environment. This study indicates that environmental contamination is separate from that of incoming raw materials and includes strains persisting, possibly for years, within the plant. Operational and sanitation procedures appear to have a significant impact on environmental contamination, with both plants having similar prevalence values for raw materials but different contamination prevalence values for the environmental sites. Plant A, which had a higher environmental contamination prevalence value, may have more potential reservoirs for *L. monocytogenes*, as it has a larger production volume, is housed in an older facility, and used continuous running water as part of processing. This study concludes that regular *L. monocytogenes* testing of drains, combined with molecular subtyping of the isolates obtained, allows for efficient monitoring of persistent *L. monocytogenes* contamination in a processing plant.
Keywords: seafood processing,* Listeria*, controls, environmental sampling

Holah, John and Richard Thorpe. 2002. Hygienic Plant Design and Sanitation. In *Foodborne Pathogens: Hazards, Risk Analysis and Control* edited by Clive de W. Blackburn and Peter J. McClure. Woodhead Publishing Limited and CRC Press LLC. Boca Raton, FL.

The primary objective of a hygienic plant design is to set up effective barriers to microbial and other contamination. Level 1 is the factory site. Issues at Level 1 include rodent control (bait), bird control (clean up spillage), insect control (screens, lighting), and avoidance of dust (good landscaping). Level 2 is the factory building. Issues at Level 2 include external environment protection and internal microbiological, chemical, and physical protection. In some factories, drainage and subsequent contamination has occurred through leakage from floors above due to floor defects and badly maintained drains. Level 3 is the internal barriers separating manufacturing processes. Processing areas should be separated from non-processing areas and high-risk areas should be separated from low-risk areas. Some ovens have been designed to drain into high-risk areas, which presents a contamination risk. Problems have also occurred with leakage of sumps under ovens, into the high-risk area. Boot baths and washes have been shown to inadequately disinfect low-risk footwear, so different boots should be worn in high-risk areas. Providing an environment in which the formation of biofilms is limited, undertaking cleaning and disinfection programs as required, and monitoring and controlling these programs to ensure their success can control the formation of biofilms. Routine cleaning operations are never 100 percent and intensive periodic cleans are required to remove the soil accumulation over time. These can include increased cleaning time, higher temperatures, alternative chemicals, and manual scrubbing. For the majority of food operations, it is necessary to use multiple cleaning products for specific operations. The efficacy of disinfectants is controlled by interfering substances, pH, temperature, concentration, and contact time. Of the acceptable chemicals, the ones most often used are chlorine-releasing components, quaternary ammonium compounds (QAC), amphoterics, and quaternary ammonium/amphoteric mixtures. Efficacy tests can be conducted to test cleaning and disinfecting agents. Cleaning equipment is prone to contamination with *Listeria* and should be specific to high-risk area and disinfected after use. Microbiological sampling can be used to assess the effectiveness of a sanitation program.
Keywords: facility design, food processing, separation, equipment, risk assessment, controls, cleaning, sanitation

Horne, C.W., L.L. Boleman, C.G. Coffman, J.H. Denton, and D.B. Lawhorn. 1989. Mycotoxins in Feed and Food Producing Crops. ***U.S. National Dairy Database.*** **http://www.mda.state.mn.us/dairyfood/mfgallergens.htm on April 23, 2003.**

Methods for detecting mycotoxin range from visual inspection made with black light to ELISA tests to complex laboratory analysis using high-pressure liquid chromatography. Aflatoxin is a major toxin group. Properly designed and operated storage facilities can prevent aflatotoxin development but field conditions, such as droughts, often cannot be altered. Grains should be removed from temporary storage as soon as possible. The major influences on growth and reproduction of mycotoxins in grains are moisture content, temperature, oxygen supply, pH, and condition of the grain. Grains should not be stored under high moisture conditions. The long-term safe storage moisture content is generally accepted to be 13 percent. Many U.S. processors have established vigorous screening programs for aflatoxins and other mycotoxins in their raw materials. Treatment with anhydrous ammonia, which breaks the bond of the aflatotoxin molecule and reduces its destructive potential, has not received full approval of the FDA but has been used in several states to treat contaminated commodities. It also has a number of disadvantages, including discoloration of the grain. Shaking out immature or broken kernels is also done.
Keywords: mycotoxin, storage, grains

Ilyukhin, Sasha V., Timothy A. Haley, and Rakesh K. Singh. 2001. A Survey of Control System Validation Practices in the Food Industry. ***Food Control*****. Vol. 12. No. 5: 297-304. [only have abstract]**

Over the last decade, there has been a significant increase in the use of digital control systems in the food manufacturing industry. The additional tasks with which digital controllers are burdened make their function much more complex than the electro-pneumatic-mechanical systems they replace. Potential control system failures can affect operator and process safety. Proper control system validation measures can prevent such potentially tragic failures. A nationwide scientific survey of US food manufacturers was conducted to generate information regarding the validation practices within the food manufacturing industry. This survey also included system integrators and equipment suppliers that sell goods and services to the US food manufacturers. It has been determined that the majority of food manufacturers delegate the responsibility for control system validation to a third-party, such as equipment supplier, system integrator or a consulting firm, with little understanding of the validation process and its importance. Only a few food manufacturing companies utilize validation resources available from equipment suppliers and system integrators. Equipment suppliers and system integrators should combine their efforts to provide the food industry with formal and comprehensive training and maintenance programs for the equipment as well as the system that controls it.
Keywords: validation, equipment, suppliers

Jackson, Lauren S.,, Tina Beacham-Bowden, Susanne E. Keller, Chaitali Adhikari, Kirk T. Taylor, Stewart J. Chirtel, and Robert I. Merker. 2003. Apple Quality, Storage, and Washing Treatments Affect Patulin Levels in Apple Cider. ***Journal of Food Protection.*** **Vol. 66, No. 4.**

Patulin is a mycotoxin produced primarily by *Penicillin expansum*, a mold responsible for rot in apples and other fruits. The growth of this fungus and the production of patulin are common in fruit that has been damaged. However, patulin can also be detected in sound fruit. This study found that dropped apples contained patulin, while tree-picked apples did not. Patulin was also discovered in unculled tree-picked apples stored at 0 to 2 degrees Celsius for 4 to 6 weeks, whereas none was found in culled tree-picked apples. Further, washing apples reduced patulin levels by 10 to 100 percent, depending on the initial patulin levels and the type of wash solution used. This study indicates that the avoidance of using dropped apples and the careful culling of apples are good methods for reducing patulin levels in apples. Washing is also useful, however, when apples are highly contaminated with patulin, washing treatments are not able to reduce patulin levels to less than 50 micrograms per liter, the FDA action level for the toxin. ***Keywords: patulin, mycotoxin, fresh produce (apples), risk assessment, controls***

Jahncke, Michael L. and Daniel Herman. 2001. Control of Food Safety Hazards During Cold-smoked Fish Processing. *Journal of Food Science*. Vol. 66 No. 7: 1104-1112.

Waters where finfish are harvested may contain bacteria or spores that may be pathogenic to humans, such as *Clostridium botulinum* and *Listeria monocytogenes*. Fish may also come in contact with pathogenic microorganisms during harvesting, handling on board, and off-loading and transportation to a smoking facility. In general, good sanitation procedures should be applied throughout harvest, transportation, storage, and postharvest handling. In the U.S., direct treatment of finfish to reduce microbial load is permitted after harvest and before processing. Chlorine solution dips, which require intense management to avoid recontamination, have been replaced by chlorine solution rinses or sprays that are followed by a rinse with potable water. The following constitute some of the potential hazards and the applicable controls for cold-smoked finfish processing:

- Incoming fish may harbor parasites and contain unsafe levels of biogenic amines. All lots of fish directly received from the harvest vessel should be accompanied by documentation certifying proper time and temperature handling of the fish.

- Contamination of the raw material or outgrowth of pathogenic microorganisms may occur if the fish is not maintained in a sanitary facility with proper refrigeration controls. Thus, fish should be stored so that their internal temperature is less than 40 degrees Fahrenheit.

- Frozen raw fish should be thawed under sanitary conditions.

- *Listeria monocytogenes* and *C. botulinum* spores present on a single fish could contaminate an entire batch within the brine solution. Thus, to minimize microbial growth and cross-contamination, temperature control of the brine solution during brining is recommended.

- Presence of sufficient salt in the fish is essential to inhibit the outgrowth of *Clostridia* species and to prevent the formation of toxins. Portions that are too thick or too large should be removed and cut to the proper size.

- Cross-contamination with *L. monocytogenes* can occur during slicing and cutting. Strict adherence to SSOPs and GMPs is essential. In particular, effective SSOPs can be used to minimize or prevent cross contamination with *L. monocytogenes*.

Keywords: seafood processing, sanitation, risk assessment, controls, cross-contamination

Keller, Susanne E., Robert I. Merker, Kirk T. Taylor, Hsu Ling Tan, Cathy D. Melvin, Stuart J. Chirtel, and Arthur J. Miller. 2002. Efficacy of Sanitation and Cleaning Methods in a Small Apple Cider Mill. *Journal of Food Protection.* Vol. 65, No. 6: 911-917.

The efficacy of cleaning and sanitation in a small apple cider processing plant was evaluated by surface swab methods as well as microbiological examination of incoming raw ingredients and of the final product. Surface swabs revealed that hard-to-clean areas, such as apple mills or tubing for pomace and

juice transfer may continue to harbor contaminants even after cleaning and sanitation. Use of poor quality ingredients and poor sanitation led to an increase of approximately 2 logs in aerobic plate counts of the final product. Reuse of uncleaned press cloths contributed to increased microbiological counts in the finished juice. Finally, using apples inoculated with *Escherichia coli* K-12 in the plant resulted in an established population within the plant that was not removed during normal cleaning and sanitation. The data presented in this study suggest that current sanitary practices within a typical small cider facility are insufficient to remove potential pathogens.
Keywords: cleaning, sanitation, cider, testing,, risk analysis, fresh produce (apples)

Kindle, Lauryn. 2001. Opening Doors to Food Safety and Sanitation. *Food Processing*. May 22.

In a recent study, it was found that doors have a significant effect on room air distribution. Food processing doors should be of corrosion-resistant materials and remain shut as much as possible to minimize the transfer of food pathogens. Most door frames are wood covered and are vulnerable to microbial contamination over time as the wood corrodes with repeated cleaning. One control developed by The Rytec Corp. of Jackson, WI is a stainless steel high-speed roll door.
Keywords: sanitation, food processing, facility design, control

Krysinki, E.P. 1992. Effect of Cleaners and Sanitizers on *Listeria monocytogenes* Attached to Product Contact Surfaces. *Journal of Food Protection.* Vol. 55, No. 4: 246-251. [only have abstract]

A variety of chemical cleaning and sanitizing compounds were evaluated for their ability to remove and/or inactivate surface adherent *Listeria monocytogenes.* Resistance of adherent cells to sanitizers was dependent upon the surface studied, being greatest on polyester/polyurethane, followed by polyester, and stainless steel. Biofilm removal with cleaners followed the same pattern, with polyester/polyurethane the most difficult to clean. Complete biofilm removal/inactivation was obtained in many cases where a surface was cleaned prior to sanitization. Listeria biofilms should be controllable by combining GMPs with HACCP.
Keywords: cleaning, sanitation,* Listeria, *biofilms, HACCP, good manufacturing practices

Kuhn, Mary Ellen. 1995. Getting Lathered up About Plant Sanitation. *Food Processing*. June.

Elimination of bacterial contamination not only improves food safety but also aids in increasing product shelf life. Thus, food processors have started giving serious consideration to how equipment should be cleaned and sanitized during the design stage. National Sanitation Foundation (NSF) has developed standards to assure that equipment can be quickly disassembled for cleaning and does not have difficult-to-clean features, such as screws or rough surfaces. Further, an increasing number of food manufacturers are looking to standardize their cleaning operations so that they can better control the end results. Some of the technologies food plants are adopting for this purpose include automated hand-washing systems, ATP bioluminescence monitoring for detection of soil or bacteria on plant surfaces, and portable sanitation equipment.
Keywords: food processing, sanitation, equipment, facility design, cleaning

Kuntz, Lynn A. 1992. Keeping Microorganisms in Control. *Food Product Design*. August.

Molds, yeast, viruses, and bacteria can cause food spoilage and more importantly food borne illness when ingested. Controlling these constitutes the most important challenge to food manufacturers. Some of the basic preventative controls that should be in place in food processing plants to control for these food safety hazards include:

- Prevention of contamination by proper cleaning of manufacturing equipment,
- Removal of microorganisms by washing, trimming, centrifuging, and filtration,
- Removal of oxygen by applying a vacuum, or the replacement of oxygen by gases, such as nitrogen or carbon dioxide,
- High or low temperature treatments depending on the type of food product,
- pH control,
- Control of water activity levels via cooking, baking, or dehydration,
- Use of preservatives or inhibitory substances that have Generally Recognized as Safe (GRAS) status, and
- Irradiation.

Keywords: food processing, cleaning, sanitation, irradiation, controls

Minnesota Department of Agriculture. 2003. Managing Food Allergen Risks. http://www.mda.state.mn.us/dairyfood/mfgallergens.htm.

Food manufacturers need to evaluate their operations and develop plans to control unidentified allergens. Evaluation of allergen hazards should be part of a HACCP plan. Non-allergenic ingredients should be considered as substitutes. Allergenic ingredients should be added at the end of a process. Equipment should be easy to clean, inspect, and maintain. Production lines should be designed to isolate allergen addition point, dedicate re-feed systems, ensure product containment, and eliminate crossover of conveyor lines. Manufacturers should ensure that suppliers have implemented and documented an allergen plan. Reconditioned ingredients and oils should not be purchased. Proper sanitation or dedicated use should be ensured regarding transportation of bulk ingredients/shipping containers that are reused. Specifications/ingredient statements should be reviewed before substituting raw materials. Production systems should be dedicated or products with allergens should be run at one time or at the end of a production run. Adequate clean up should be performed between runs. A documented rework plan should be available. All rework should be clearly labeled. Labels on incoming ingredients should be checked. Label accuracy should be verified. The use of “may contain” labeling in lieu of GMPs should be limited. Outdated packaging materials should be removed from plants. Product traceability systems should be in place and verified. Sanitation practices should be validated using sight, bioluminescence testing, and ELISA testing. Maintenance tools should be checked to make sure that they are not potential vectors for cross-contamination. Employee practices for sanitation should be specified and employees should receive good training and education about allergens.

Keywords: allergens, HACCP, controls, equipment, facility design, suppliers, sanitation, labeling, packaging, maintenance

Morris, Charles E. 2002. Best Practices for Allergen Control. *Food Engineering.* March.

The basic allergen control strategy is similar at many companies. The big eight allergens include peanuts, tree nuts, milk, eggs, soybeans, finfish, shellfish, and wheat. The first step in formulating a product is to eliminate allergens if possible or add them in towards the end of the process. Dedicated production lines are also a preferred strategy while a portion of a given line can also be dedicated. Many food plants were not designed with allergen control in mind, such as where a product on an upper conveyor can drop on a product on the conveyor below. Covering the conveyors can solve this problem. "Hang-ups", where product residues can collect to be swept up in a later production run, can be contained by cleaning, isolating, or sealing off allergen-addition points on the line. Color coding maintenance tools can prevent cross-contamination. Full ingredient lists should be obtained from raw material suppliers and audits should be conducted to help assure that allergens are properly identified in raw materials and ingredients. Best practices can also include longer production runs with minimal changeovers for high-volume products. Where changeovers are necessary, products containing allergens can be scheduled last in the production cycle to minimize cross-contamination and cleanup. To prevent packaging mix-ups, old packaging should be discarded and a tracking system should be used. ELISA (enzyme-linked immunoabsorbent assays) tests, developed by FARRP and Neogen, can validate the effectiveness of an allergen cleaning program. A HACCP-like approach and employee training are also important. Allergens should be evaluated with a HACCP-like approach, with process areas identified as high-risk considered as critical control points. Employee training is also very important to the success of allergen control.
Keywords: allergens, best practices, facility design, equipment, packaging, cleaning, testing, HACCP, employee training

Morris, Charles E. 2000a. Best Manufacturing Practices. *Food Engineering.* February.

Food Engineering conducted a survey of an Executive Advisory Panel, consisting of more than 400 food-manufacturing professionals in various roles in the industry, to share manufacturing improvements implemented in the past five years and how they achieved these improvements. HACCP programs were established by 75 percent of panelists and 79 percent have improved employee training in plant sanitation and food safety. More than 65 percent of panelists regularly review and document GMPs, SOPs, and SSOPs, while 62 percent conduct independent audits or inspections, to better assure plant sanitation and food safety. Forty-five percent added equipment of sanitary design and 39 percent replaced equipment with new equipment with a more sanitary design. Thirty-eight percent increased lab testing and 32 increased QA staff. One-third of panelists implemented or increased use of microbial detection systems. Only 9 percent of the panelists reported that their plants had appointed a HACCP coordinator with no other responsibilities and of those, half were meat processors. When asked about maintenance, 71 percent of panelists apply preventive maintenance, but 28 percent practice reactive maintenance.
Keywords: best practices, HACCP, sanitation, good manufacturing practices, facility design, equipment, maintenance

Morris, Charles E. 2000b. HACCP Under the Microscope. *Food Engineering.* October.

According to the 2000 Food Engineering's Best Manufacturing Practices Survey, 75 percent of respondents have established HACCP programs in their plants. More than two-thirds of respondents in every industry outside of meat, poultry, and seafood, have voluntarily implemented HACCP. HACCP has gained acceptance in industries where it is not required, but compliance and enforcement problems have arisen in industries that do require it. Compliance failures include weak prerequisite programs (SSOPs, GMPs, QA programs, consumer complaint monitoring, environmental monitoring, vendor certification, and allergen management), "half-way" HACCP programs due to lack of upper-management commitment,

product releases despite CCP violations, inclusions of quality components in HACCP that dilute its effectiveness, weak CCP validations and hazard analyses, inadequate/inefficient documentation, inadequate training, and a lack of continuous improvement.
Keywords: best practices, HACCP, compliance

Mortimore, Sara. 2003. Problems Encountered Applying the HACCP Approach to Food Safety: If HACCP can Work so Well, Then Why do so Many Businesses Have Problems With It? *FoodInfo Online Features*. IFIS Publishing. January 27. www.foodsciencecentral.com.

HACCP can be seen as an unnecessarily burdensome and bureaucratic activity among food manufacturers. Implementation of an effective HACCP plan requires education on (1) food borne illness and trends, (2) why HACCP is a minimalist system that ensures maximum control, and (3) how it can help reduce sanitation costs and down time, and lengthen shelf life, improve efficiency, and reduce waste. The cause of many of the problems of implementation can be traced back to the decision to adopt HACCP and the reasons why it was chosen. While it seems that the best HACCP systems are developed by businesses that are driven to self-improvement, the prompt may also come from regulators and customers. The lack of understanding of the HACCP concept or methods, as well as a lack of appropriate microbiological and toxicological knowledge, often leads to over-reliance on advice from many quarters, and can result in over-complex HACCP systems. This is further confounded by reliance on “off-the-shelf” HACCP packages, inadequate or improperly deployed generic plans and consultant plans that do not fit the business. This is particularly relevant for small and medium-sized enterprises (SMEs) but also for many larger companies. In the industry, there is a shift towards second generation HACCP models that allow greater flexibility and that emphasize prior development of effective prerequisite hygiene programs. Another prime requirement for effective implementation of HACCP programs is having an understanding of the people that will be responsible for operating the system and providing adequate training. [Note: Article is based on the U.K experience of HACCP implementation. Thus, the findings may not be fully applicable to the U.S.]
Keywords: HACCP, implementation, sanitation, employee training

Moss, Maurice. 2002. Toxigenic Fungi. In *Foodborne Pathogens: Hazards, Risk Analysis and Control* edited by Clive de W. Blackburn and Peter J. McClure. Woodhead Publishing Limited and CRC Press LLC. Boca Raton, FL.

Toxigenic fungi are found primarily in foods of plant origin, such as cereals, legumes, oilseeds, and treenuts. They may also pass through food in chain in milk and meat. Controls for aflatotoxin (occurring in corn and treenuts) include preventing insect damage, alleviating drought stress, and reducing water activity in the product. Controls for ochratoxin A (occurring in coffee, cocoa, vine fruits, spices, cereals) include prevention of mold growth at every stage of the production process. Removing moldy apples, conversion to cider, treatment with activated charcoal or sulfur dioxide can control Patulin (occurring in apple juice). Fumosin (occurring in corn) elimination is difficult. Ear rot and insect damage are associated with high levels of infection. The breeding of cultivars resistant to such damage is a possible control strategy. The possibility of biological control in the field is also being investigated.
Keywords: fungi, risk analysis, controls

Moulton, Curtis J. 1992. Reducing Pesticide Residues in Food. *Food Safety and Quality.* June.

While FDA reports that 96 percent of all foods have safe levels of pesticide residue or none, consumers remain concerned. Pesticide residues can be controlled by reducing dependence on them through organic

production systems, integrated pest management, and low input sustainable agriculture (LISA). Other farm industry efforts include development of safer chemicals and genetically engineered, pest-resistant plants.
Keywords: pest control, organic production, chemical hazard, risk assessment

Murphy, R.Y., L.K. Duncan, K.H. Driscoll, B.L. Beard, M.B. Berang, and J.A. Marcy. 2003. Determination of Thermal Lethality of *Listeria monocytogenes* in Fully Cooked Chicken Breast Fillets and Strips during Postcook In-package Pasteurization. *Journal of Food Protection.* Vol. 66, No. 4: 578-583.

The presence of *Listeria monocytogenes* in processing environments renders meat or poultry products at risk for contamination after cooking and before packaging. This study evaluates the post-cook in-package pasteurization on eliminating *Listeria monocytogenes* from three types of vacuum-packaged fully cooked chicken breast meat products that were treated with continuous pilot scale steam or hot water cooker. Results indicate that both steam and hot water pasteurization are effective for the inactivation of *Listeria monocytogenes* in fully cooked and vacuum-packaged chicken breast meat products.
Keywords: meat processing, poultry processing,* Listeria*, packaging, pasteurization, controls

National Food Processors Association (NFPA). Undated. *Industry Position on Control of Listeria Monocytogenes, With Emphasis on Meat and Poultry Products*. National Food Processors Association. www.nfpa-food.org.

Listeriosis is a serious disease that is primarily transmitted through a limited number of foods. Specifically, it appears that foods that support the growth of pathogenic *Listeria monocytogenes* over the shelf life of the product, especially foods given a listericidal process which have become recontaminated, pose the greatest risk to consumers. Control of *L. monocytogenes* has proven to be a difficult challenge in food processing establishments that manufacture RTE products that are not treated in their final package to eliminate this organism. In 1999, the food industry reviewed and revised suggested programs designed to minimize the presence, survival, and multiplication of *L. monocytogenes* in foods. These programs include:

- Applying a validated listericidal process where appropriate,
- Purchasing from suppliers with a *Listeria* control program,
- Minimizing the potential for recontamination,
- Adopting new technologies as soon as they are available, and
- Implementing an environmental monitoring program for *Listeria* spp. to verify that the control program is effective.

In addition to modifying in-plant practices and upgrading verification programs, many in industry are also seeking long term and more dependable solutions to this problem, such as in-package pasteurization with heat or ionizing radiation, use of ionizing radiation, and product reformulation to retard or preclude growth of *L. monocytogenes*.
Keywords: food processing,* Listeria*, ready-to-eat, controls, suppliers, packaging, pasteurization

Neff, Jack. 1999. Beyond Chlorine. *Food Processing*. January 1.

Chlorine has been the disinfectant of choice for the food and beverage manufacturing industry for years. Despite its widespread use, chlorine usage is not problem free. In water with high levels of organic residue, chlorine dissipates quickly. Using too much chlorine to compensate, however, can lead to the formation of excessive hypochlorous acid that causes chlorine to volatize more rapidly creating fumes that can pose hazards to plant workers. Further, one food processor found chlorine to be ineffective in sunlight or if it has warmed up significantly above room temperature. Thus, it is difficult to find the right level of chlorine needed to kill all the microorganisms without leaving too much chlorine or volatile fumes behind. An alternative to chlorine is peroxyacetic acid that one frozen vegetable processing facility is currently using. Although it costs 50 to 100 percent more than chlorine, the agent reportedly provides improved microbial control and safety. Other emerging disinfecting technologies include ozone and ultraviolet radiation.
Keywords: food processing, disinfectant

Olson, Alan R. 2002. Hard or Sharp Objects. *Compendium of Fish, Fishery Product Processes, Hazards, and Controls.* October.

Foreign objects can be broadly classified as food safety hazards (e.g., glass) and food non-safety hazards (e.g., filth). Foreign objects that are physical hazards are referred to as hard or sharp objects. Hard or sharp objects are further divided into metallic objects, which are divided into ferrous and non-ferrous metals, and non-metallic objects. Controls for metal inclusion can include periodic checks of metal equipment and passing the product through metal detectors or separation equipment. Glass can be controlled by visual examination of empty glass containers containing transparent product, cleaning with water or compressed air and inverting empty glass containers, periodically monitoring lines for glass breakage, proper adjustment of capping equipment, and passing the product through an x-ray system. Non-metallic objects can also be detected by an x-ray system.
Keywords: seafood processing, physical hazards, risk analysis, controls

Park, Douglas L., Henry Njapau, and E. Boutrif. 1999. Minimizing Risks Posed by Mycotoxins Utilizing the HACCP Concept. *Food, Nutrition, and Agriculture.* No. 23.

Prevention through pre-harvest management, such as enforcing effective insect control programs and maintaining adequate irrigation schedules, is the best way to control mycotoxin formation. Field crops should be harvested in a timely manner and damage kept to a minimum during harvesting to prevent infestation of mycotoxins. Extraneous material should be removed and products should be dried rapidly to under 10 percent moisture. In the post-harvest phase, storage and processing are the major areas where contamination can be prevented. An accumulation of moisture and heat and/or physical damage can increase the likelihood of mycotoxins. Appropriate packaging or general hygiene are generally useful in minimizing damage from insect infestation. Product should be stored on a dry, clean surface. During processing, mycotoxins can be intentionally eliminated or introduced. Control procedures that can be employed include clean up and separation, thermal inactivation, and chemical inactivation. For example, electronic sorting and hand-picking can remove a significant proportion of aflatoxins in shelled peanuts. Complete separation of all contaminated particles may not be achieved, however, and other procedures have to be used to manage contamination in the final product. Thermal inactivation is a good alternative, although aflatoxins and deoxynivalenol are resistant to heat. Other potential control processes include ammoniation and activated carbons and clays.
Keywords: mycotoxins, HACCP, prevention, risk assessment, separation, controls

Paulson, Daryl S. 1996. To Glove or to Wash: A Current Controversy. *Food Quality*. June/July.

Both hand washing and using gloves have their adherents and detractors. The article argues that using these in tandem may be the most effective solution, combined with vigorous enforcement and employee training, and an environmental sanitation program. An intact glove provides adequate protection from microbial transmission of hand-contaminating microorganisms. However, some food-grade gloves may have existing pinhole punctures and/or can be easily ripped, torn, or punctured during use. While hand washing, on the other hand, can be very effective in removing microorganisms, ensuring that food workers perform effective hand washes is difficult. Thus, the study recommends (1) donning of gloves to be preceded by an effective hand wash, (2) ongoing employee training and education, (3) high personal hygiene requirements, and (4) institution of a quality control program to monitor and enforce hand washing and gloving sanitation practices. Further, to reduce disease transmission by contaminated objects, the study suggests an effective environmental and sanitation program and restriction of tasks among workers to prevent contamination in addition to the previously noted four controls.
Keywords: employee training, employee hygiene, sanitation, controls

Raloff, Janet. 1998. Staging Germ Warfare in Foods. *Science News*. Vol. 153. No. 6. February 7.

Many bacteria generate small proteins known as bacteriocins. Bacteriocins function as unusual, narrow-spectrum antibiotics. They tend to harm only microbes that closely resemble the bacteria that manufactured them. In many cases, bacteriocins attack potentially fatal food-poisoning germs, such as *Listeria monocytogenes* or the *Clostridium* responsible for botulism. A number of studies on foods ranging from pasteurized egg products, hot dogs, poultry summer sausage to meat products, have shown promising results where the bacteriocins added were effective in killing certain types of pathogens.
Keywords: pathogens, control, bacteriocins

Riordan, D. C. R., G. M. Sapers, T. R. Hankinson, M. Magee, A. M. Mattrazzo, and B. A. Annous. 2001. A Study of U.S. Orchards To Identify Potential Sources of *Escherichia coli* O157:H7. *Journal of Food Protection.* Vol. 64, No. 9: 1320-1327.

Fourteen U.S. orchards were surveyed in autumn 1999 to determine the incidence and prevalence of *E. Coli* O157:H7, *E. Coli,* total aerobic microflora, and yeasts and molds. Fruit was also tested for internalization of microflora by aseptically removing the core, stem, and calyx areas, and the individual sections were assessed for the categories of microflora listed above. Findings suggest that dropped or damaged fruit should not be included in fruit designated for the production of unpasteurized juice or for the fresh or fresh-cut market. In addition, orchards should be located away from potential sources of contamination, such as pastures.
Keywords: fresh produce,* E. Coli*, risk analysis

Rushing, J.E. and H.P. Fleming. 1999. Scheduled Processes. Department of Food Science, Food Processing. FSE 99-21.

A scheduled process is a process selected by a processor as adequate for use under the conditions of manufacture for a food in achieving and maintaining a food product that will not permit the growth of microorganisms having public health significance. A scheduled process must be established by a qualified person or a competent process authority, with expert knowledge acquired through appropriate training and experience in the acidification and processing of acidified foods. The key to safe preservation of acidified

foods is the maintenance of an adequately low pH in the finished product to prevent growth and toxin production by the *Clostridium botulinum* bacterium. Acidified foods must have a finished equilibrium pH of 4.6 or lower. While a pH of 4.6 or lower is adequate to prevent growth and toxin production by *Clostridium botulinum*, it may not be adequate to prevent growth of other microbiological pathogens. Thus, acidified foods must be thermally processed to an extent that is sufficient to destroy the vegetative cells of microbes of public health significance and those of non-health significance that can grow in the product under the conditions in which it is stored, distributed, and held by the consumer.
Keywords: scheduled process, acidified foods

Senkel, I. Arthur, Robin A. Henderson, Beverly Jolbitado, and Jianghong Meng. 1999. Use of Hazard Analysis Critical Control Point and Alternative Treatments in the Production of Apple Cider. *Journal of Food Protection.* Vol. 62, No. 7: 778-785.

The purpose of this study was to evaluate the practices of Maryland cider producers and determine whether implementing hazard analysis control point (HACCP) would reduce the microbial contamination of cider. Cider producers were surveyed to determine existing manufacturing practices and sanitation. A training program was then conducted to inform operators of safety issues, including contamination with *Escherichia coli* O157:H7, and teach HACCP concepts and principles, sanitation procedures, and good manufacturing practice (GMP). Although all operators used a control strategy from one of the model HACCP plans provided, only one developed a written HACCP plan. None developed specific GMP, sanitation standard operating procedures, or sanitation monitoring records. Six operators changed or added production controls, including the exclusion of windfall apples, sanitizing apples chemically and by hot dip, and cider treatment with UV light or pasteurization. Facility inspections indicated improved sanitation and hazard control but identified ongoing problems. Microbiological evaluations of bottled cider before and after training, in-line apples, pomace, cider, and inoculated apples was conducted. *E. Coli* O157:H7, *Salmonella, or Staphylococcus aureus* were not found in samples of in-line apple, pomace, and cider, or bottled cider. Generic *E. Coli* was not isolated on incoming apples but was found in 4 of 32 (13%) in-line samples and 3 of 17 (18%) bottled fresh cider samples, suggesting that *E. Coli* was introduced during in-plant processing. To produce pathogen-free cider, operators must strictly conform to GMPs and sanitation procedures in addition to HACCP controls. Controls aimed at preventing or eliminating pathogens on source apples are critical but alone may not be sufficient for product safety.
Keywords: cider,* E. Coli*, HACCP, sanitation, fresh produce (apples), risk assessment, controls

Siddiqi, Zia. 2001. New Technologies in Pest Management Prevent Pathogen Spread. *Food Processing*. February 21.

Because of their behavior, biology, and morphology, insect and rodent pests serve as exceptional disease vehicles for harboring and rapidly transporting diseases. In the food handling environment, the three main pests that have been known to transmit pathogens are rodents, roaches, and flies. An integrated pest management program (IPM) is necessary to eliminate insect and rodent pests and hence the spread of pathogens from these sources. IPM relies on inspection, monitoring, establishing action threshold levels, and implementing first non-chemical and then chemical measures. IPM also involves communication and education. Some of the newer technologies, such as computer-aided monitoring and nonvolatile nonrepellant insecticide formulations, enable the placement of control agents in precise locations thereby eliminating the possibility of pathogen spread.
Keywords: pest control, handling, pathogens

Snowdon, J.A. and D.O. Cliver. 1996. Microorganisms in Honey. *International Journal of Food Microbiology*. Vol. 31. No. 1-3: 1-26. [only have abstract]

Microbes of concern in post-harvest handling are those that are commonly found in honey (i.e., yeasts and sporeforming bacteria), those that indicate the sanitary or commercial quality of honey (i.e., coliforms and yeasts), and those that under certain conditions could cause human illness. Primary sources of microbial contamination are likely to include pollen, the digestive tracts of honey bees, dust, air, earth, and nectar, which are very difficult to control sources. The same secondary (after-harvest) sources that influence any food product are also sources of contamination for honey. These include air, food handlers, cross-contamination, equipment, and buildings. Secondary sources of contamination are controlled by good manufacturing practices (GMPs). Routine microbiological testing of honey is necessary to control for microorganisms. The testing might include standard plate counts for general information, specialized tests (such as yeast counts and an assay for bacterial spore formers), and coliform counts for checking sanitary quality.
Keywords: honey, risk assessment, controls, handling, testing

Sommers, Christopher, Michael Kozempel, Xuetong Fan, and E. Richard Radewonuk. 2002. Use of Vacuum-Steam-Vacuum and Ionizing Radiation To Eliminate *Listeria innocua* from Ham. *Journal of Food Protection.* Vol. 65, No. 12: 1981-1983.

Vacuum-steam-vacuum (VSV) technology is known to successfully to eliminate *Listeria innocua* from hot dogs and ionizing radiation has been used to eliminate *Listeria* spp. from RTE meats. The application of these technologies can cause changes in product quality. This study investigated the ability of VSV and ionizing radiation, together, to eliminate *Listeria innocua* from ham meat and skin. The use of both treatments resulted in an additive reduction of *L. innocua* on ham. The combination treatment did not cause statistically significant changes in product quality.
Keywords: meat processing,* Listeria*, controls

Stier, Richard F. 2002. Validating Safety in Your Plant. *Food Engineering*. September.

The root cause of most food borne illness is often a breakdown in plant sanitation. Changes in operations can have profound and often devastating effects on the plant sanitation system. Construction projects and increases in production volume have the potential to adversely affect safety. For example, *Listeria* contamination resulting from construction operations has been cited as a cause of one of the largest recalls of processed meats in recent history. Plants need to ensure that changes are undertaken in an orderly and controlled fashion to ensure food safety.
Keywords: sanitation, validation, construction, risk analysis

Stier, Richard F. 2001. Foreign Materials in Foods: Are They Really Dangerous? *Market Pulse.*

Sources of foreign materials include inadvertent materials from the field (e.g., stones, metal, insects, undesirable vegetable matter, dirt, or small animals), inadvertent results from processing and handling (e.g., bone, glass, metal, wood, nuts, bolts, screening, cloth, grease, paint chips), materials entered during distribution (e.g., insects, metal, dirt, stones), materials intentionally placed in food (employee sabotage), and miscellaneous sources (e.g., struvite). Mechanical harvesters often collect more than just the product and so processors include destoners, air cleaners, magnets, screens and washers as part of their lines. Grain processors and manufacturers used four screens to remove foreign materials. Preventive maintenance is important in preventing foreign materials from entering the processing operation and is

considered a HACCP prerequisite. Properly maintained equipment and lines usually do not cause problems. All packages should be designed to prevent tampering after the container is sealed. Packages should be examined for insect or rodent infestation that came from the exterior. The greatest concern with contamination during distribution and storage is bulk products. Employee sabotage is difficult to monitor. Controls include good management and proper employee education. A good QA system and good line workers are essential. Struvite, a hard crystalline material that can be formed in canned proteinaceous seafoods, is also hard to control. It resembles glass and can break a tooth, but will not cut like glass. Stone and wood, based on the author's experience, are usually foreign materials that are controlled by HACCP and are not common. Glass can be controlled by policies that require throwing away all containers within 10 feet of the breakage and shielding lights. Scanning for glass on-line is possible too, although expensive. Metal is a common industry concern and best addressed by preventive maintenance. Ferrous materials can be removed by magnets. Metal detectors are also becoming more common, especially in the meat sector. In sum, the following practices should be followed: plant audits that evaluate systems for pest control, foreign object removal, plant condition, shipping and receiving practices, and plant maintenance procedures; a review of packaging materials and container/package handling procedures; a review of agricultural practices; a review of personnel practices; package evaluation to ensure it is tamper proof; a review of consumer complaints to see whether foreign materials are an issue. These steps should be part of a HACCP program.
Keywords: physical hazards, HACCP, maintenance, equipment, packaging, controls

Stopforth, J.D., J. Samelis, J. N. Sofos, P. A. Kendall , and G. C. Smith.. 2002. Biofilm Formation by Acid-Adapted and Nonadapted *Listeria monocytogenes* in Fresh Beef Decontamination Washings and Its Subsequent Inactivation with Sanitizers. *Journal of Food Protection.* Vol. 65, No. 11: 1717-1727.

Despite conventional cleaning methods, such as washing and sanitizing, pathogenic bacteria can remain on equipment surfaces and contaminate food. This study investigated the effect of various sanitizers on *Listeria monocytogenes* cells in suspension and those attached to a surface by means of a biofilm (slime layer to which pathogenic bacteria can attach and grow). The study results indicate that attached cells are more resistant than cells in suspension to the effects of sanitizers. Further, the study indicates that each sanitizer has an optimal working environment in which it is most effective.
Keywords: sanitation, biofilms, **Listeria**

Suttajit, Maitree. 1989. Prevention and Control of Mycotoxins. *Mycotoxin Prevention and Control in Foodgrains.*

The inhibition of fungal growth can be achieved by physical, chemical, and biological treatment. This includes drying (less than 9 percent moisture for peanut and less than 13.5 percent moisture for corn) and proper storage after harvest, such as maintenance of the container/warehouse at low temperature and humidity and keeping insects out. Various chemical treatments have been used and are the most effective means to remove mycotoxins from contaminated commodities as compared to hand picking, organic solvents, heating and cooking, or ionizing radiation.
Keywords: mycotoxins, prevention, controls

Thimothe, Joanne, Jonathan Walker, Voranuch Suvanich, Ken L. Gall, Michael W. Moody, Martin Wiedmann. 2002. Detection of Listeria in Crawfish Processing Plants and in Raw, Whole Crawfish and Processed Crawfish (*Procambarus spp.*). *Journal of Food Protection.* Vol. 65, No. 11: 1735-1739.

This study monitored the presence of *L. monocytogenes* and other *Listeria* spp. in the processing environment, in raw, whole crawfish, and in cooked crawfish meat from two processing plants. Although *Listeria innocua* was the predominant *Listeria* spp. found (20 samples), four samples were positive for *L. monocytogenes. L. monocytogenes* was detected in three raw material samples and in one environmental sample. *Listeria* spp. were found in 29.5% of raw, whole crawfish (n = 78) and in 4.4% of environmental samples (n = 181) but in none of the finished product samples. Among the environmental samples, *Listeria* spp. were found in 15.4% of the drains (n = 39) and in 5.1% of the employee contact surfaces (gloves and aprons) (n = 39) but in none of the samples from food contact surfaces. Even though a high prevalence of *Listeria* spp. was detected on raw materials, it appears that the heat treatment during the processing of crawfish and the practices preventing post-processing recontamination can significantly reduce *Listeria* contamination of RTE crawfish meat.
Keywords: seafood processing,* Listeria*, risk assessment

Thomas, Ingram, Bevis, Davies, Milne, and DelvesBroughton. 2002. Effective Use of Nisin to Control Bacillus and Clostridium Spoilage of a Pasteurized Mashed Potato Product. *Journal of Food Protection*. Vol. 65. No. 10: 1580-1585. [only have abstract]

Heat-resistant spore-forming bacteria, such as Bacillus and Clostridium, can survive and grow in cooked potato products. The natural food preservative nisin is used in heat-treated foods to prevent the growth of such bacteria. The study shows that nisin remains at effective levels after pasteurization and extends shelf life of the product by at least 30 days. The ingredients and the preservatives, however, must be well mixed to ensure nisin efficacy.
Keywords: bacteria, pasteurization, cooked product (potatoes), controls

Tilden, John Jr., Wallace Young, Ann-Marie McNamara, Carl Custer, Barbara Boesel, Mary Ann Lambert-Fair, Jesse Majkowski, Dur Vaga, S. B. Werner, Jill Hollingsworth, and J. Glenn Morris. 2002. A New Route of Transmission for *Escherichia coli*: Infection from Dry Fermented Salami. *American Journal of Public Health.* Vol. 85, No. 8: 1142-1145.

This study evaluated the production of dry fermented salami associated with an outbreak of *Escherichia coli* O157:H7 infection in Washington State and California. Facility inspections, review of plant monitoring data, food handler interviews, and microbiological testing of salami products were conducted. Production methods complied with or exceeded federal requirements and industry-developed good manufacturing practices. No evidence suggested that post-processing contamination occurred. This study suggests that *E. Coli* O157:H7 may have been present on raw meat and subsequently survived the currently accepted processing methods.
Keywords: meat processing,* E. Coli*, risk analysis, post-processing

Tompkin, R.B. 2002. Control of *Listeria monocytogenes* in the Food Processing Environment. *Journal of Food Protection.* Vol. 65, No. 4: 709-725.

Recontamination is the primary source of *Listeria monocytogenes* in many commercially prepared ready-to-eat processed foods. Product testing will not indicate the mode of contamination or how to prevent

further occurrences. Environmental testing is better and more cost-effective in detecting the mode of contamination and enabling timely corrections. Listeriosis can occur in isolated cases or as a cluster of cases due to a contaminated lot of food, both of which are generally due to errors in food handling. Outbreaks of a few to several hundred cases that are scattered with regards to time and location are typically due to the establishment of the pathogen in a niche, which is a site within the manufacturing environment in which *Listeria monocytogenes* becomes established and multiplies. These niches may be impossible to reach and clean with normal cleaning and sanitizing procedures and continue to contaminate food during processing operations. Environmental and equipment testing is necessary to detect niches. The sampling sites should include areas that are good indicators of control, like food contact surfaces. The food processing environment should be sampled at least weekly. It should be noted that while *Listeria monocytogenes* can be reduced, it cannot be eliminated from the environment. Continued improvements in equipment design are necessary to make cleaning more effective and to minimize breakdowns and repairs. There will be increased use of post-packaging pasteurization with irradiation, hot water, steam, and high pressure in the future.
Keywords: food processing,* Listeria*, ready-to-eat, testing, risk analysis, controls

Tybor, Phillip T., William C. Hurst, A. Estes Reynolds, and George A. Schuler. 1990. Preventing Chemical Foodborne Illness. *The University of Georgia College of Agricultural and Environmental Sciences Cooperative Extension Service.* November. http://www.ces.uga.edu/pubcd/b1042-w.html.

Chemical hazards include metals, pesticides, intentional food additives, and other chemical residues. The residues, if consumed in large enough quantities, can be harmful to humans. Some agents implicated in chemical foodborne illness are beneficial and essential in the diet as nutrients, others preserve food and others are part of food plant sanitation. Chemical foodborne illness is usually the result of human error. With regards to metal poisoning outbreaks, the source is primarily food handling equipment and utensils made of inappropriate materials. When high-acid foods come into contact with the equipment or utensil, corrosion occurs and is leached into the food. This can occur with citrus fruits, fruit drinks, fruit pie fillings, tomato products, sauerkraut, and carbonated beverages. Pesticide contamination can occur due to spills, indiscriminate spraying of food-handling facilities or equipment, improper storage of pesticides or mistaken identity, and incomplete washing of fruits and vegetables. Possible controls include storing and securing pesticides away from food products, maintaining the chemical in its original container, reading and following instructions on the label, handling pesticides like poisons, avoiding indiscriminate application of pesticides, and using trained and certified personnel for pesticide application. Some food additives can cause health problems in sensitive individuals. FDA requires declaration on labels of sulfites at 10 ppm or higher. Sodium nitrite, a controlled additive, must be stored in a locked cabinet and weighed and bagged separately before addition to any product. Unintentional food additives, such as detergents, cleaning compounds, drain cleaners, polishers, and sanitizers can best be controlled by properly training personnel about cleaning and sanitizing, reading and following label instructions, storing chemicals away from food, maintaining chemicals in their original containers, avoiding use of empty cleaning chemical containers for food storage, using only approved food grade lubricants and greases, and keeping an inventory of these chemicals in a secure, supervised area.
Keywords: chemical hazards, equipment, risk assessment, controls, storage, employee training

USDA/ARS. 2002. Food Safety: National Program Annual Report FY 2002.

Aflatoxin is found in peanuts, corn, cottonseed, tree nuts and figs. Fumosins are found in corn and deoxynivalenol is found in wheat and barley. Scientists have demonstrated that gallic acid is an inhibitor of aflatotoxin in some tree nuts. High humidity and rainfall were found to stimulate aflatotoxin

production in cottonseed. Providing improved management recommendations may prevent the occurrence of aflatotoxin in cottonseed.
Keywords: mycotoxins, control, prevention

USDA/FSIS. 2002. Guidance for Minimizing the Risk of *Escherichia coli* O157:H7 and *Salmonella* in Beef Slaughter Operations. September.

Despite good slaughter practices, which are also detailed in this guidance, contamination of carcasses can still occur. Post-slaughter antimicrobial decontamination methods can be used to address this issue, including spray-washing, steam-vacuuming, steam pasteurization, warm water wash, trimming, lactic acid decontamination. Chilling and finished product storage at temperatures that preclude pathogen growth are also post-slaughter processes that aid in minimizing contamination risks.
Keywords: meat processing,* E. Coli*, risk analysis, controls

USDA/FSIS. 2001. Controlling *Listeria monocytogenes* in Small and Very Small Meat and Poultry Plants. September.

Contamination of foods with *Listeria monocytogenes* most frequently occurs when a product or food contact surface is contaminated between the cooking and packaging steps. Control methods include the following sanitation steps: dry cleaning, pre-rinsing equipment, foaming and scrubbing, rinsing, visual inspection of equipment, cleaning walls and floors, sanitizing, and drying. Also, environmental and contact surface testing should be done to determine the effectiveness of cleaning and identify potential sources of contamination. Sanitizers that have proven most effective include quaternary ammonia compounds, chlorine solutions and products containing peracetic acid. Rotating sanitizers periodically is a good practice as it is more effective against *Listeria monocytogenes* and other bacteria. Alternating between alkaline and acid based detergents also helps to avoid soapstone or hard water buildups and the formation of biofilms and to alter the pH of the environment to prevent adaptation of the bacteria. Plants must be designed to eliminate traffic flow between RTE and raw product areas. RTE areas should have dehumidifiers and drip pans that are sanitized regularly. Ceilings, floors, and walls should be smooth, sealed, and moisture free. Air supply should be filtered. Light fixtures should be designed so that they do not harbor dirt or moisture. Environmental testing of non-food contact surface, food contact surface testing, and product testing can be conducted in-house by an establishment. Results, however, should be validated on a regular basis by a third party.
Keywords: meat processing, poultry processing,* Listeria*, controls, sanitation, testing, facility design, ready-to-eat

Walker, Elizabeth, Catherine Pritchard, and Stephen Forsythe. 2003. Food Handlers' Hygiene Knowledge in Small Food Businesses. *Food Control*. Vol. 14. No. 5: 339-343. [only have abstract]

Personal interviews were conducted with 444 food handlers in 104 small food businesses regarding their knowledge of food hygiene. The study reports that 57 percent of food handlers thought that they could tell if food was contaminated with food poisoning bacteria by sight, smell, and taste. Roughly, 25 percent of the interviewees thought that bacteria readily multiplied at –10, 75, or 120 degrees Celsius. Around 16 percent thought that the correct temperature of a refrigerator was –18 degrees Celsius or below. The study demonstrated that the basic lack of hygiene knowledge and understanding could prove to be a major barrier to the effective implementation of HACCP in small food businesses in the U.K.
Keywords: employee hygiene, handling, HACCP, implementation

Young, Renee. 2003. Rethinking Sanitation. *Food Engineering*. March 29.

Manufacturers must adopt a holistic view of plant sanitation from how ingredients are delivered to the shipment of finished goods. This includes not only rethinking the sanitation of processing systems but of all the building systems, including electrical fixtures and duct work. With the advent of PLC, PC and CIP systems that measure the temperature, cleaning fluid mix, and pressure used in a cleaning session, operators can correct the problem immediately. In the majority of smaller plants, equipment is not designed to be cleaned with the help of automation. Plants have different types of equipment that range in age and design, making it virtually impossible to set up a spray pattern that will automatically and effectively clean each or provide accurate measurements. In such plants, manufacturers are placing more emphasis on the employees. Many companies are transferring sanitation from the third shift to the first or second and staffing those shifts with better-trained employees. Other plants are working to fully automate their sanitation systems, eliminating the possibility of human error. Further, concern over the use of toxic chemicals in sanitation procedures and the cost associated with their handling and disposal has many manufacturers looking for safer alternatives. Ozone is making strides as a safe alternative and a powerful oxidant that destroys microbes. For example, salad maker, Sandridge Food Corp., uses aqueous ozone to disinfect celery and its associated equipment. Plumrose USA Inc., a processor of ham, turkey, chicken, and deli meats, uses ozonated water to sanitize work areas and processing equipment used for slicing and packaging and to rinse its stainless steel transportation racks.
Keywords: sanitation, facility design, equipment, employee training