# THE ROLE OF SLAUGHTER HYGIENE IN FOOD SAFETY

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## Contents





## Summary

In recent years, some highly publicized outbreaks of foodborne disease caused by pathogenic bacteria, such as *Escherichia coli* O157:H7, have increased consumer concerns and interest in food safety. As a result, regulatory authorities and the industry have undertaken efforts to improve sanitary conditions and the microbiological quality of meat and poultry. Actions taken by the Food Safety and Inspection Service (FSIS) of the United States Department of Agriculture (USDA) include the "Cattle Clean Meat Program" and the "Zero Tolerance" policy of 1993, which instructed inspectors to enforce the requirement of knife-trimming for removal of all visible physical contaminants from carcasses prior to washing and chilling; and the enforcement of new inspection regulations for meat and poultry, which require establishment of sanitation standard operating procedures, operation under the hazard analysis critical control point (HACCP) food safety management system, and establishment of microbiological performance criteria and standards for *Escherichia coli* biotype I and *Salmonella* levels of contamination as a means of verifying proper application of HACCP. These

developments have emphasized the need for sanitary and hygienic practices and for application of procedures to reduce levels of contamination (i.e., decontamination procedures) on carcasses. Here, we discuss the importance of animal and bird cleanliness, sanitation, hygienic practices and carcass decontamination in contributing to the improvement of the microbiological safety of our meat and poultry supply. Specific items discussed include animal cleanliness; washing/cleaning and chemical dehairing of animals before slaughter; scalding and feather-picking; use of equipment which applies steam or hot water plus vacuuming for spot-cleaning/decontamination of carcasses; washing of birds before and after scalding plus after picking; variable pressure spraying/rinsing of carcasses or carcass sides with chemical solutions such as chlorine, organic acids and trisodium phosphate, or with low or high temperature water; exposure of carcass sides to pressurized steam ("steam pasteurization"); chilling of birds in chlorinated water; and importance of proper hygienic and sanitation practices during chilling, fabrication and further processing of meat and poultry.

## 1. Introduction

Potential food safety hazards associated with consumption of products of animal or plant origin include those of physical, chemical and biological nature. Physical hazards include foreign objects such as stones, bones, glass, metal, insects, pests, mice, building material, etc. Such unwanted materials are aesthetically unacceptable and may cause physical and psychological injury to consumers. However, they can be controlled through adherence to good manufacturing practices (GMP) and use of devices such as metal detectors. Chemical hazards include naturally occurring toxins, excessive residues of agricultural chemicals, intentional or accidental food additives, detergents, sanitizers and other plant-associated toxic substances that may contaminate food. They can also be controlled through proper application of good production and manufacturing practices as well as establishment and monitoring of standards, guidelines or specifications.

Biological hazards include those of bacterial, parasitic, viral and prion nature. Prions are transmissible particles, devoid of nucleic acid, which become aberrant proteins causing transmissible spongiform encephalopathy (TSE). Important TSEs include sheep scrapie (sheep spongiform encephalopathy), human Creuztfeldt-Jacob Disease (CJD) and its new variant form (nvCJD), and mad cow disease or bovine spongiform encephalopathy (BSE). The latter TSE was detected in cattle in the United Kingdom in the 1980s and it is believed to be the cause of nvCJD in humans. However, measures such as destruction of infected cattle and changes in feeding regimes to exclude reclaimed products/byproducts from sheep or other ruminants have decreased dramatically the incidence of BSE in cattle.

Although parasitic and viral hazards are associated with foodborne illness in some instances, their control depends on prevention of their introduction into the food. Because parasites and viruses are not able to proliferate in harvested or ready-to-eat foods, their control depends on proper processing (e.g., freezing, cooking, etc.) of foods, and avoidance of contamination of ready-to-eat products.

Bacterial pathogens are the major cause of food safety problems in terms of occurrence

and number of individuals affected. Among others, common bacterial pathogens associated with meat and poultry products include *Campylobacter jejuni/coli*, *Salmonella* spp., *Escherichia coli* O157:H7, and *Listeria monocytogenes*. In addition to discomfort, these pathogens sometimes cause death of susceptible individuals and their cost to national economies may be very high. Therefore, it is important to know the ecology and properties of these pathogens in order to develop procedures for their control and for enhancement of the safety of our food supply. Control of pathogenic microorganisms in foods is based on the approaches of minimizing product contamination through good production and manufacturing practices, proper sanitation and hygiene, and application of decontaminating procedures; destruction of contaminants by processes such as heat or irradiation in some products; or, inhibition/delay of their growth and multiplication through food preservation methods such as refrigeration, freezing, drying, fermentation, acidification, pasteurization, chemical preservatives or combinations of these in the form of multiple hurdles.

Many bacterial pathogens are of intestinal origin and thus are associated with meat and poultry products. There is a need to study their ecology and to develop procedures that minimize their presence on fresh meat and poultry. The subject addressed here is reduction of contamination in meat and poultry which should enhance the efficacy of other control procedures such as cooking, and should decrease the likelihood of food safety problems.

Fresh meat and poultry are easily contaminated with a variety of microorganisms and, if not properly handled and preserved, they support growth of spoilage and pathogenic species, leading to loss of quality and potential public health problems. Microorganisms are introduced through a variety of sources when the sterile muscles of healthy animals and birds are exposed to the environment during slaughter, cutting and further handling. These sources include air, water, soil, feces, feed, hides, hair, feathers, wool, intestines, lymph nodes, processing equipment, utensils and humans. The multiplicity of contamination sources and the variability in facilities and practices of slaughtering and processing operations may lead to variations in types of microorganisms and, especially, extent of contamination introduced in meat and poultry, which may also vary with individual herds or flocks, animals or birds, geographic location and season of the year. Cleanliness of animals and birds is an important factor affecting the contamination of meat and poultry and is influenced by climate, location, method of transportation and holding conditions. For example, animals or birds raised on pastures or out-of-doors may carry more bacteria of soil origin, while microorganisms of intestinal origin may be more common on carcasses from animals finished in feedlots or in confined flocks. Additional contamination may be derived from exposure to the environment of the slaughtering, dressing, chilling and cutting processes, while carcass decontamination interventions may reduce levels, and change the composition, of contamination. Thus, types and extent of contamination also depend on sanitation procedures, hygienic practices, product handling and processing, and conditions of storage and distribution.

Since early in the twentieth century, regulatory inspection activities have been applied to assure the hygienic status of the meat and poultry supply. These traditional regulatory requirements include veterinary inspection of live animals and birds, their carcasses and organ tissues following slaughter, inspection of facilities and equipment before and

during operation, and supervision of procedures involved in meat and poultry handling and processing. These activities should prevent meat and poultry from overtly diseased animals or birds and visibly contaminated, not properly processed, or abused, products from reaching the consumer. Regulatory requirements, proper facility designs and good manufacturing practices, as well as other industry initiatives based on competition, product quality, long-distance shipment, distribution requirements and economics of operation, have extended product shelf-life and improved quality, but have not prevented microbiological contamination of raw products or eliminated foodborne diseases.

## 2. Animal cleaning and washing

In general, the muscles of healthy animals and birds, before slaughter, are considered sterile, while lymph nodes, some organs, and, especially, surfaces exposed to the environment, such as external hide, pelt, feathers, or fleece, the tongue and the gastrointestinal tract carry extensive contamination. This external, animal-associated contamination is a major source for environmental plant contamination, and becomes a very important source of carcass and meat/ poultry contamination during slaughtering and processing. Every feasible effort should be made to prevent accumulation of excess mud and dung on the animals and birds, because it may introduce bacterial pathogens into the plant environment. Confinement of animals and birds, intended for slaughter in properly designed facilities, with slatted floors and/or on clean bedding material can help in presentation of cleaner animals and birds for slaughter. Avoidance of stress and maintenance of a proper feeding schedule may reduce release or shedding of microorganisms by animals and birds with their feces and the contribution of this fecal material to undesirable plant and carcass contamination. However, additional research is needed to establish proper handling procedures to minimize fecal shedding of pathogenic bacteria of intestinal origin by animals and birds.

It has been suggested that one, seemingly obvious, approach that may contribute to the reduction of external animal contamination, and subsequently, carcass contamination is to clean or wash the outside covering (hide, skin, feathers) of the animals before slaughter. Individual operations have evaluated, or applied interventions, such as removal (by cutting or shearing ) of hair or wool and fecal tags from the exterior of the animals or washing of animals before slaughter, but in many instances the results are generally less than promising. Pre-slaughter washing of sheep has been practiced in New Zealand, while partial or complete washing of cattle before slaughter has been used by some plants in the United States. Counts of total aerobic bacteria and *Escherichia coli* on lamb carcasses were higher on those washed before slaughter, irrespective of wool length, and were generally greater on carcasses derived from woolly lambs than on those derived from shorn lambs. Results of preslaughter washing of lambs were not consistent between forequarters and hindquarters, but there was less visible contamination on the carcasses of washed lambs than on those of unwashed lambs. The level of microbiological contamination of carcasses from the best-presented animals (shorn, clean, unwashed) was five times lower than that from the worst presented animals (wooly, dirty, washed). In general, the results of animal washing before slaughter have been variable and application of the procedure may be limited by climate, type of animal, and availability of facilities. Regulatory guidelines in the

United States require cattle to be dry, or at least not dripping, when they are slaughtered, which can be a constraint when animal washing is considered before slaughter. However, when animals are wet or excessively soiled, slaughter speeds should be reduced to minimize accidental transfer of contamination from the exterior of the animals onto the carcass or the plant environment. In addition, modifications in the steps involved in hide removal, or in equipment used for hide removal, may help in minimizing transfer of contamination onto the carcass surface. No effort is made to clean feathers and skin of poultry because, following stunning/bleeding, suspended birds are washed with chlorinated water.

The contribution of animal and bird cleanliness to carcass contamination levels needs additional study. The results may be variable depending on slaughtering procedures, speed of slaughter, facility design, and worker practices. One approach that may help in the reduction of carcass contamination with pathogens may be to process highly contaminated or infected animals separately from cleaner or pathogen-free herds or flocks. This approach, however, may be impractical in some systems of animal and bird production, marketing, distribution, and slaughtering, or for control of more than one type of pathogenic microorganisms on the same animals or birds. Another approach to prevent foodborne illness from contaminated meat and poultry may be to produce heat processed products from meat and poultry derived from animals or birds suspected of carrying pathogenic contamination. Nevertheless, highly soiled animals and birds are an important potential source of plant contamination. However, poor sanitation, hygiene and manufacturing practices during slaughtering, carcass cutting (fabrication) and processing can lead to excessively contaminated meat and poultry, even when less heavily soiled animals and birds are processed.

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**Biographical Sketches**

**Gary C. Smith** occupied the Monfort Endowed Chair in Meat Science at Colorado State University in 1990, after serving as Professor (1969-1982) and Head (1982-1990) of the Department of Animal Science at Texas A&M University.

Gary has won both the Distinguished Research Award and the Distinguished Teaching Award from both the American Society of Animal Science and from the American Meat Science Association. He has also been awarded the National Association of Meat Purveyors—Outstanding Educator Award, the National Livestock Grading and Marketing Association—Service Award (three times; in 1979, 1988 and 1995), the Livestock Publications Council—Headliner Award, and was named one of the "25 Who Made a Difference" by Beef magazine. In 1993, he was named a University Distinguished Professor by Colorado State University and a Fellow-In-Teaching by the American Society of Animal Science; in 1994 he was named one of six "Industry Innovators" by Meat Marketing and Technology magazine. He has been named a Distinguished Alumni by College of the Sequoias (1989), California State University-Fresno (1996) and the Washington State University (1999). He has received Meritorious Service Awards from Intercollegiate Meat Coaches Association (1997), American Meat Institute (1997), National Meat Association (1998) and Secretariat of Agriculture of Argentina, Service (1998).

Gary has published 346 full-length articles in refereed scientific journals and more than 675 other contributions as proceedings, technical reports, etc. Gary served as President of the American Meat Science Association in 1976. For the National Academy of Sciences, he was chairman of the Committee that wrote "Irradiation of Meat and Meat Products" and a member of the Committee that wrote "Designing Foods." For the Office of Technology Assessment, he was a member of the Committee that wrote "Packaging and Labeling of Fresh Red Meat."

**John N. Sofos** holds a B.S. degree in Agriculture from the Aristotle University of Thessaloniki, Greece, a M.S. degree in Animal Science from the University of Minnesota, and a Ph.D. degree in Food Science from the University of Minnesota. Dr. Sofos accepted an Assistant Professor position in the Department of Animal Sciences at Colorado State University in 1980, and he was promoted to Associate Professor and Professor in 1984 and 1987, respectively. Courses taught by John Sofos at Colorado State University include Food Processing Technology, Food Fermentations, Food Microbiology, Food Biotechnology, and Meat Safety. Current research interests of John Sofos address the areas of ecology and extent of bacterial pathogen contamination of meat and other foods; procedures to reduce contamination and to inactivate or inhibit bacterial pathogens; resistance of microorganisms to preservation procedures; and methods of sampling and detection of bacteria in foods. Based on his research accomplishments, Dr. Sofos has approximately 400 publications, including 110 refereed journal articles, 2 books, 127 abstracts, 20 book chapters, 44 articles in conference proceedings, and over 40 invited papers at national and international meetings. The professional contributions of John Sofos have been recognized with the Distinguished Meat Research Award of the American Meat Science Association (1994), the Meats Research Award of the American Society of Animal Science (1996), and the Faculty Award of Merit for Research and Outreach of the Colorado State University Chapter of Gamma Sigma Delta (1998). John Sofos was

elected Fellow of the American Academy of Microbiology in 1995 and of the Institute of Food Technologists in 1997, and serves as Scientific Co-Editor of the Journal of Food Protection published by the International Association of Milk, Food and Environmental Sanitarians. He has been invited to lecture in several countries, including England, the Netherlands, Japan, Indonesia, Canada, Spain, Greece, Australia, and New Zealand.