

# Food Safety for the 21st Century

Managing HACCP and Food Safety  
Throughout the Global Supply Chain

Carol A. Wallace  
William H. Sperber  
Sara E. Mortimore



 WILEY-BLACKWELL

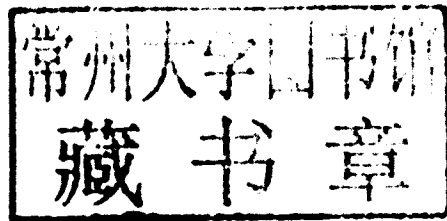
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# **Food Safety for the 21st Century**

To Christopher, Renate and Lawrence for their encouragement to develop  
this book and for their steadfast support of our careers and families

*and*

To all participants in the global food supply chain from farm to table whose  
combined efforts are essential to provide a safe supply  
of food for all consumers

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# Preface

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The effective development and management of food safety programmes are essential to minimise the occurrence of foodborne illnesses and outbreaks. However, that responsibility is increasingly difficult to fulfil because of the growing human population and the rapidly growing global food trade. With our diverse professional experiences, we three authors have a combined experience of about 90 years in food research, management and education focused on food safety and quality practices. We have undertaken to write *Food Safety for the 21st Century* in an effort to assist all participants in the global food supply chain from farm to table to fulfil their individual responsibilities for food safety assurance. This book should be an excellent textbook in academic food safety courses and an excellent reference book for food safety researchers, managers and regulators worldwide. We wrote this book to be comprehensive and forward looking, with sufficient technical detail to support the complete range of food safety activities from hazard analyses and training programmes to regulation and policy development.

Future demands on the global food supply will challenge our ability to provide a sufficient supply of food that is reliably safe for consumption. The human population, projected to increase by 3 billion people by 2050, and the improving economic status in developing countries mean that we will need to double food production over the next 40 years, and all this in the context of climate change, the diminishing availability of fresh water, fossil fuels and arable land, and the emergence and spread of new foodborne pathogens. The emergence and mismanagement of the bovine spongiform encephalopathy (BSE) epidemic 25 years ago vividly demonstrate the necessity of improving food safety management practices from farm to table and throughout the global supply chain.

The Hazard Analysis and Critical Control Point (HACCP) system of food safety management began as a voluntary food industry effort nearly 40 years ago. Assisted by the Codex recommended code of practice for good hygienic practices and HACCP, first published in 1992, global food corporations have implemented HACCP wherever possible in their particular parts of the supply chain. Yet, our industry efforts to maximise the benefits of effective food safety management programmes have been hampered by fragmented governmental regulatory responsibilities and practices in many countries, especially by the promulgation of counterproductive food safety regulations in some countries.

Some governmental regulatory bodies seem incapable of doing more to develop and promulgate effective food safety regulations that will support the global food industry in its mission to ensure the safety of the food supply. Therefore, achieving effective food safety assurance in the global supply chain will likely require intergovernmental harmonisation of food safety regulations and practices and creation of a global food protection organisation.

The challenges facing all of us in our quest to maintain and improve food safety practices may seem daunting, but they are not insurmountable. There are large reservoirs of available food safety talent in the industry, academia, public health organisations and regulatory bodies. We

need to generate the collective political will to collaborate and provide competent management and effective food safety management practices, effective educational programmes, and practical regulations. Working together, we will meet our challenges.

Bon appétit!

Carol A. Wallace  
William H. Sperber  
Sara E. Mortimore

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# Acknowledgements

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**Jose Chipollini, MoArk LLC, USA**

**Erica Sheward, Global Food Standards, UK**

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# Disclaimer

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The material in this book is presented after the exercise of care in its compilation, preparation and issue. However, it is provided without any liability whatsoever in its application and use.

The contents reflect the personal views of the authors and are not intended to represent those of the University of Central Lancashire, Cargill Incorporated, or Land O'Lakes, Inc.



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# How to use this book

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*Food Safety for the 21st Century* is split into three main parts:

Part 1: Food Safety Challenges in the 21st Century

Part 2: Foodborne Hazards and Their Control

Part 3: Systematic Food Safety Management in Practice

In addition, there are two appendices providing HACCP and food safety case studies of example links in the global food supply chain and a resource section to help the reader find information and help in applying food safety.

This book is intended to be a compendium of up-to-date thinking and best practice approaches to the development, implementation and maintenance of world-class food safety programmes. Whilst some readers may wish to read the book from cover to cover, we anticipate that many readers will dip into the specific sections, chapters and appendices at different parts of their food safety journey. The book is written both for those who are developing food safety management systems for the first time and for those who need to update, refresh and strengthen their existing systems. The following paragraphs provide an outline of the content of each part and ideas of how they may be used.

Part 1, *Food Safety Challenges in the 21st Century*, sets the scene by providing a discussion of the key considerations for food safety in our modern world. Starting with a consideration of where we have come from and how contemporary food safety programmes have evolved (Chapter 1), this part continues by considering lessons learned from food safety successes and failures (Chapter 2) and looks at challenges in the global food supply chain (Chapter 3). This part finishes with consideration of the future of food safety and HACCP in our changing world (Chapter 4), allowing us to look forward and predict some of the actions that need to be taken to continually improve and strengthen our food safety programmes and approaches in the global supply chain.

This part will provide the reader with a detailed understanding of the context within which food safety management must operate. It will outline the key food safety considerations for individuals, businesses and organisations involved in the global food supply chains of the 21st century.

Part 2, *Foodborne Hazards and Their Control*, consists of three chapters which together form a database of information enabling the reader to recognise food safety hazards and design safe products and processes. This will be useful at the product development stage to provide an understanding of some of the key hazards and control mechanisms available to the food business, and will also be invaluable to HACCP team members who need to understand the likely hazards in their operations.

Part 3, *Systematic Food Safety Management in Practice*, outlines how to develop, implement and maintain world-class food safety programmes based on safe product/process design, prerequisite programmes and HACCP. The seven chapters of this part provide a detailed understanding of current thinking on food safety management, drawing on the experiences and learnings of the past 40 years to offer best practice approaches for developing or strengthening an effective food safety programme.

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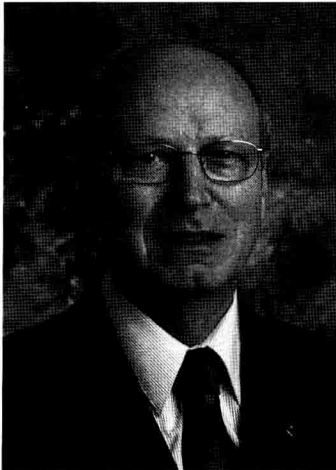
## The authors

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**Carol A. Wallace** is Principal Lecturer, Food Safety Management at the University of Central Lancashire, UK, where she is a course leader for postgraduate food safety and HACCP programmes and leads research themes in food safety effectiveness. Having entered the food industry as a microbiology graduate, she very soon became involved in the early days of HACCP and food safety management systems in the UK and went on to gain 20 years of practical experience in the UK and international food industry prior to joining academia 5 years ago. She gained a PhD for her study of factors impacting HACCP effectiveness and continues to work closely with international food companies and organisations for the ongoing improvement of food safety standards.



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**William H. Sperber** studied biological and chemical sciences at the University of Wisconsin, Madison, culminating in a PhD degree in microbiology. This 'friendly microbiologist' has worked in research and management positions with major global food companies for more than 40 years, the majority with the Pillsbury Company, where the HACCP system of food safety management originated. In his current retirement career, Bill is Cargill's Global Ambassador for Food Protection, in which capacity he proposed and continues to promote the development of a global food protection organisation.



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**Sara E. Mortimore** has many years of food manufacturing experience in food safety and quality management. She is currently Vice President of Quality Assurance and Regulatory Affairs, at Land O'Lakes, Inc., one of the US premier farmer-owned cooperatives operating in both the food and agricultural sectors, including dairy products, eggs, animal feed, seed and crop protection. Previously, she worked in various international roles covering quality, food safety and global sourcing for Pillsbury and General Mills. During this time, she gained a deep cultural understanding of the attitudes and behaviours of people towards food safety in manufacturing around the globe. She graduated in the UK in food science and went on to gain a master's degree in training and development. As a result of this, she has developed a major interest in the development of integrated food safety management using the HACCP approach and in adequate training interventions that are aligned to the needs of workers and the abilities of trainers.

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# Glossary of terms and acronyms

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- Aerobe** A microorganism that can grow in the presence of oxygen. Obligate aerobes, for example moulds, cannot grow in the absence of oxygen.
- Allergen** A compound capable of inducing a repeatable immune-mediated hypersensitivity response in sensitive individuals.
- Anaerobe** A microorganism that can grow in the absence of oxygen. Obligate anaerobes, for example *Clostridium* spp., cannot grow in the presence of oxygen.
- Audit** A systematic, independent and documented process for obtaining audit evidence and evaluating it objectively to determine the extent to which the audit criteria are fulfilled (ISO, 2002).
- Audit criteria** A set of policies, procedures or requirements. Audit criteria are used as a reference against which the actual situation is compared (ISO, 2002).
- Audit evidence** Records, statements of fact or other information, which are relevant to the audit criteria and verifiable (ISO, 2002).
- Audit findings** Results of the evaluation of the collected audit evidence against audit criteria (ISO, 2002).
- Auditee** Organisation being audited (ISO, 2002).
- Auditor** The person with the competence to conduct an audit (ISO, 2002).
- BRC** British Retail Consortium, based in London, UK, and one of the GFSI benchmarked food safety certification scheme standard owners.
- CFR** Code of Federal Regulations, a repository of US regulations.
- CFSA** Canadian Food Safety Agency.
- COA** Certificate of Analysis that would accompany a product or raw material and indicate compliance to specification.
- Codex** Codex Alimentarius Commission (CAC), a United Nations organisation that supports FAO and WHO by developing food standards, guidelines and codes of practice.
- Control measure** An action or activity that can be used to prevent, eliminate or reduce a hazard to an acceptable level.
- Corrective action** Any action to be taken when the results of monitoring at the CCP indicate a loss of control (Codex 2009b).
- Critical control point (CCP)** A step at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level (Codex, 2009b).
- Critical limit** A criterion that separates acceptability from unacceptability (Codex, 2009b).
- Crohn's disease** A chronic inflammatory bowel disease of humans, thought to be caused by *Mycobacterium paratuberculosis*.
- D-value** The process time required to reduce a microbial population by 90%, or one log<sub>10</sub> unit.
- Dutch HACCP Code** An auditable standard based on the principles of HACCP, prerequisite programmes and management procedures.
- Emerging pathogen** Typically, an uncommon pathogen that becomes more prevalent because of changes in the host, the environment or in food production and consumption practices.

- Enterotoxin** A toxic molecule produced by a microorganism that causes gastrointestinal illness symptoms such as vomiting and diarrhoea.
- Essential management practices (for food safety)** Management practices and procedures that support effective application of safe product/process design, prerequisite programmes and HACCP systems, and ensure their ongoing capability to protect the consumer.
- Extremophile** A microorganism that can survive and grow under very extreme conditions such as high temperature or pressure, and extreme acidity.
- Extrinsic** A factor or process that is applied externally to a food, such as heating or modified atmosphere packaging.
- Facultative** A microorganism that can grow in the presence or absence of oxygen, a class that includes most foodborne microbes.
- FAO** The Food and Agriculture Organization of the United Nations, primarily responsible for food security.
- Food defence** Having a system in place to prevent, protect, respond to and recover from the intentional introduction of contaminants into our nation's food supply, designed specifically to cause negative public health, psychological and/or economic consequences (Yoe *et al.*, 2008).
- Food protection** All measures and programmes in place to protect the safety of the food supply.
- Food security** The state existing when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life (WHO, 2010).
- Gantt chart** A diagrammatic representation of a project plan, including actions and timetable.
- GFSI** The Global Food Safety Initiative, organised through CIES, the Consumer Goods Forum.
- GIFSL** Global Initiative for Food Systems Leadership run by the University of Minnesota.
- GMPs** Good Manufacturing Practices.
- Guillain–Barré syndrome** A syndrome involving neurological complications that are often induced as a sequel to microbial infections, often attributed to *Campylobacter*.
- HACCP** Hazard Analysis and Critical Control Point, a preventive system of food safety management based on product design, hazard analysis and process control.
- HACCP plan** A document prepared in accordance with the principles of HACCP to ensure control of hazards that are significant for food safety in the segment of the food chain under consideration (Codex, 2009b).
- HACCP team** A specific group of individuals with multidisciplinary expertise and experience who work together to apply the HACCP principles.
- Halophile** A microorganism that can grow at very high sodium chloride concentrations, for example *Halobacterium* spp.
- Hazard** A biological, chemical or physical agent in, or condition of, food with the potential to cause an adverse health effect.
- Hazard analysis** The process of collecting and evaluating information on hazards and conditions leading to their presence to decide which are significant for food safety and therefore should be addressed in the HACCP plan.
- Hydrophilic** The tendency of a polar compound to be soluble in water.
- ICD** Industry Council for Development.
- IFST** The UK Institute of Food Science and Technology.
- ILSI** The International Life Sciences Institute.
- Immunocompromised** A condition in which the host's immunity to infection is diminished by factors such as age (very young or very old), illness or chemotherapy.
- Infection** An illness or condition caused by the growth of a microorganism in a host.

- Infectious dose** The number of microorganisms required to cause an infection.
- Intoxication** An illness or condition caused by the ingestion of a toxin.
- Intrinsic** A property that is an inherent characteristic of a food, such as pH or water activity.
- ISO** International Organization for Standardization.
- Johne's disease** A chronic disease of cattle characterised by diarrhoea and emaciation, caused by *Mycobacterium paratuberculosis*.
- Lipophilic** The tendency of a non-polar compound to be soluble in fats or oils.
- Mesophile** A microorganism that grows optimally at intermediate temperatures, for example 20–45°C.
- Monitoring** The act of conducting a planned sequence of observations or measurements of control parameters to assess whether a CCP is under control (Codex, 2009b).
- NACMCF** The US National Advisory Committee on Microbiological Criteria for Foods.
- OIE** World Organization for Animal Health.
- Operational limit** A value that is more stringent than a specific critical limit that is used in process management by providing a buffer zone for safety.
- Operational PRP** A PRP identified by the hazard analysis as essential in order to control the likelihood of introducing food safety hazards to and/or the contamination or proliferation of food safety hazards in the product(s) or in the processing environment (ISO, 2005a).
- Opportunistic pathogen** A relatively harmless microorganism that can more easily cause an infection in an immunocompromised person, or if it is accidentally inserted into a sterile host site.
- Osmophile** A microorganism, particularly a yeast, that can grow under conditions of high osmotic pressure, typically created by concentrated sugar solutions.
- Osmotolerant** A microorganism that can survive high osmotic pressure.
- PAS** Publicly Available Specification.
- PMO** The US Pasteurized Milk Ordinance.
- Prion** A misshapen cellular protein that causes the agglomeration of normal-shaped prion proteins which in turn can cause transmissible spongiform encephalopathies, fatal brain diseases, such as BSE ('mad cow disease').
- Process flow diagram** A diagrammatic representation of the process, identifying all processing activities, which is used as the basis for hazard analysis.
- PRP** Prerequisite programmes such as good agricultural, manufacturing and hygienic practices that create the foundation for a HACCP system.
- Psychrotroph** A microorganism that grows optimally at low temperatures, for example 0–20°C.
- Sanitary operating practices** A term describing certain hygienic practices that form part of prerequisite programmes.
- Significant hazard** Hazards that are of such a nature that their elimination or reduction to an acceptable level is essential to the production of safe foods (ILSI, 1999).
- SQA** Supplier quality assurance. The programmes used to manage suppliers of raw materials, packaging and contract manufacturing.
- SQF** Safe Quality Food, one of the GFSI benchmarked food safety certification schemes, originated in Australia but now based in the United States.
- Thermophile** A microorganism that grows optimally at high temperatures, for example 45–70°C.
- Toxic dose** The amount of toxin required to cause a food intoxication.
- Toxin** A chemical or microbial metabolite that can cause toxic effects when ingested.

- Validate** To investigate and prove the effectiveness of a control measure, such as the critical limits, at a critical control point.
- Validation** Obtaining evidence that the elements of the HACCP plan are effective (Codex, 2009b).
- Verification** The application of methods, procedures, tests and other evaluations, in addition to monitoring, to determine compliance with the HACCP plan (Codex, 2009b).
- Verify** To confirm the continuing effectiveness of a control measure through process or records observations or analytical testing.
- WHO** The United Nations World Health Organization, primarily responsible for public health.
- World-class food safety programme** A programme based on the principles of safe product/process design, prerequisite programmes and HACCP that is supported by essential management practices, thus controlling the operational, environmental and process conditions necessary for consumer health protection through the consistent production of safe food.
- WTO** The United Nations World Trade Organization, where Codex guidelines and codes have the force of law among signatory members.
- Xerotroph** A microorganism, typically a mould, that can grow under very dry conditions.
- Z-value** The change in temperature (°C) required to change the D-value by 90% or one log<sub>10</sub> unit.
- Zoonotic** A pathogenic organism that can infect humans and animals.



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