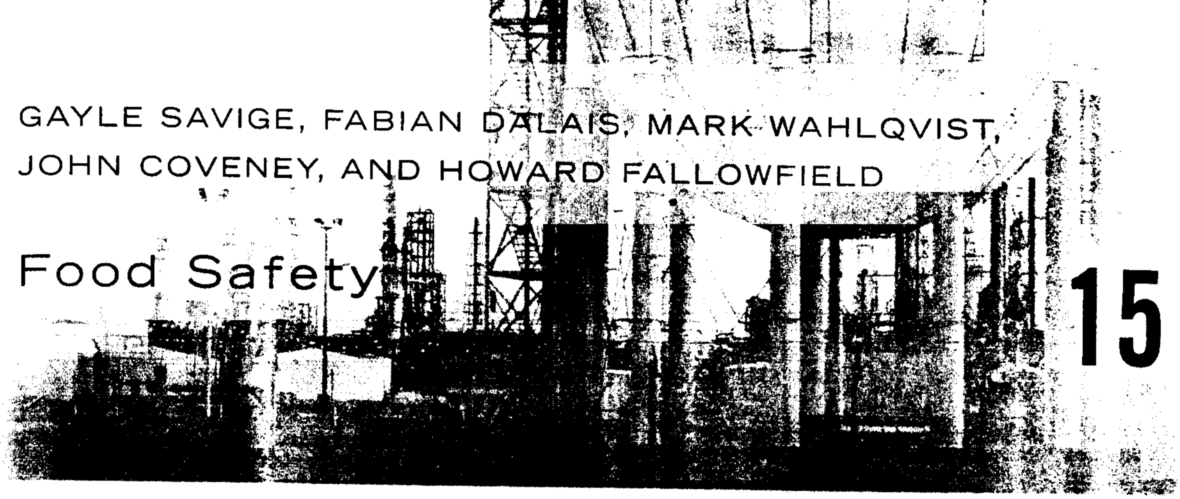

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Food Safety

15

DEFINITIONS AND BRIEF HISTORY

Food safety issues in Australia and New Zealand are constantly changing as food production, technology, trade, and food preferences and risk perceptions alter. In the days of the hunter–gatherer, differentiating poisonous from non-poisonous plants was probably the primary food safety concern of those times. As different cultures evolved, other food safety issues (either real or perceived) became more prominent. For example, in Australia and New Zealand it is illegal to sell dog meat for human consumption, yet this meat is considered acceptable and safe in many other countries. Organic foods have grown in popularity in recent years due to an increasing awareness that foods grown in the presence of fertilisers or pesticides may be harmful to health.

Food consumption patterns were previously strongly influenced by locality and seasonal availability as long transportation times (in Australia) and poor refrigeration technology limited the variety of foods that could be obtained readily (Teow et al. 1988; Wood 1988). Today, the diversity and availability of food products in Australia and New Zealand is enormous. Lester (1994) estimates Australian supermarkets stock between 8000 and 15,000 different food items, which represents an eight- to fifteen-fold increase in the last 50 years.

In this chapter food safety is defined as measures to avoid consumption of unsuitable food that could cause either acute or chronic harm to health. The major areas of food safety include microbial safety, chemical safety, and nutritional safety. An in-depth case study on setting standards for microbiological safety is featured on the CD-ROM that accompanies this text (Case Study 4: Using the 'risk' framework to review a microbiological food standard).

MICROBIOLOGICAL SAFETY

Microorganisms are ubiquitous in food, except for those foods processed to be sterile. The majority of these organisms pose little threat to human health (although they can adversely affect food quality by causing food spoilage and reducing the shelf life of the food), however, microorganisms capable of causing disease may also be present in foods.

Box 15.1 Potential sources of microorganisms in food

Agricultural environment

This includes organisms associated with faeces, such as *E.coli*, salmonellae, and *Listeria*. These may, for instance, contaminate cows' udders and be transferred to milk during milking. Mastitic cows may also contaminate milk with various organisms including *Staphylococcus aureus*. However, *Lactobacilli* and *Streptococci* have been responsible for yoghurt production through the ages. Microorganisms from animal skins may also contaminate carcasses during slaughter.

Animal feeds

Poultry feed may be a source of salmonellae, while dust from automatic feeders may result in significant atmospheric contamination, which may affect the health of the animal (for example, pneumonia in pigs). Bovine spongiform encaphalitis (BSE), of current concern to the British and Japanese beef industries, originated from inadequately heat-treated feed containing sheep brains, possibly contaminated with prions.

Soil and water

Crop irrigation contaminates produce with microbial flora similar to that found in soil and water; environmental factors (such as wind and rain) result in their translocation to foods.

Air and dust

These predominantly comprise Gram-positive flora, such as *Bacillus* spp, *Streptococcus* spp, yeasts, moulds, and fungi. They require constant re-suspension into the air (through, for example, wind action, traffic, or air conditioning) to contaminate food products.

Plants and plant products

This is a selective environment and only those organisms that are adapted survive (for example, those that can adhere to plant surfaces). Many of these natural contaminant bacteria have been utilised over the millennia for natural food fermentations, such as sauerkraut, which is cabbage fermented by *Pediococcus, Leuconostoc,* or *Lactobacilli.*

Intestinal tract of animals and humans

Enterobacteriaceae (such as *E. coli*, *Enterobacter,* and salmonellae) are found in the intestinal tract and faeces of animals. The muscles of healthy animals are normally sterile, and contamination with faeces at slaughter and during processing results in contamination of meat. Water contaminated with faecal material that contacts food may also become a source of contamination.

Food contact surfaces

The build-up of microorganisms in food processing environments leads to an almost constant inoculum for foods coming into contact with such surfaces (for example, slaughterhouse knives, butchery cutting blocks, bacon slicers, cutlery, pumps, pipes, and fittings).

Food handlers

Environmental contaminants from the atmosphere, pets, soil, and water may be transferred to foods via food handlers. Contamination of foods from hands, nasal passages, and the mouth (*S. aureus*), as well as from the gastrointestinal tract (*E. coli*, salmonellae) may contaminate foods through poor personal hygiene.

The sources of microorganisms found in foods are considered in box 15.1. The microbial ecology of food—that is, the number and genera of microorganisms present—is influenced by both intrinsic factors (for example, pH, water activity, oxidation/reduction potential, and nutrient content of the food) and extrinsic factors (for example, temperature and storage atmosphere). The numbers of microorganisms in foods, except those produced by microbial fermentation, should be as low as achievable by good manufacturing practice to maintain both public health and product shelf life.

With a quest for convenience, and foods prepared for us by others, there is less personal involvement and less need for understanding of each step in the food chain. As a consequence the transfer of traditional food safety knowledge and skill is more limited and the likelihood of error in consumer choice increased. Again, the training needs of food producers and handlers are increased because there are relatively more of them and because they are increasingly engaged in food preparative techniques that are not part of an individual's domestic, cultural, or technological experience. Some of the most notable examples of convenience and food safety are shown in table 15.1.

Assessment of microbial quality of food

The microbial quality of food may require determination to ensure the food meets:

- a microbiological standard for regulatory purposes (for example, Australian Food Standards Code 1992)
- a microbiological guideline or microbiological limit as part of a manufacturer's quality control programme for a specific product, or as part of an agency's inspection programme
- a microbiological specification as part of a contractual agreement between a buyer and seller.

The sampling of foods should always be conducted using a sampling plan. ICMSF (1986) has published and promoted attribute sampling plans, which are related to the perceived risk to the consumer. The *Australian Foods Standards Code* (ANZFA 1992) incorporates the ICMSF approach. A sampling plan should explicitly state: the microorganisms of concern requiring enumeration (for example, *Escherichia coli* or *Salmonella*); the number and the size of samples to be tested; the analytical methodology; the criteria; and the number of samples passing or failing the criteria (count per g or ml) used to attribute acceptance or rejection of the food for

Table 15.1 Food convenience and safety.

Antecedent Food Practice	Contemporary or Emergent Practice	Safety Measures Available
Sandwiches made at home or on the job	Sandwich bars become more popular and exotic by way of fillings and breads; the scale of risk of food-borne illness goes from the family to involve the community.	Time to preparation Storage arrangements Toasting (e.g. focaccia)
Home-prepared main meals	Meal delivery to homes, especially to vulnerable groups (e.g. aged, immunodeficient).	Temperature checks Transport arrangements Heating or cooking immediately prior to consumption (e.g. microwave)
Poultry on special occasions only and often home-killed	Chicken available ready-to-eat at fast food outlets and eaten much more often at home, but without commensurate increase in knowledge of how to handle chicken meat safely.	Food preparation skills that acknowledge risk of Salmonella, Campylobacter, and Listeria infection
Limited use of salad vegetables	Public health nutrition emphasis on a wide range of fruit and vegetable intake, and community interest in freshness.	Storage practice to minimise exposure to Listeria Education of vulnerable groups to avoid unsafe food choices
Regular egg consumption	Decrease egg consumption to reduce risk of cardiovascular disease because of cholesterol content (which could have been achieved almost as well by reduced co-ingestion of saturated fat) leading to food insecurity for vulnerable groups like the aged, and lack of familiarity with safe egg handling.	Resumption of basic knowledge and skills about eggs, their handling, and nutrition value

cont.

Table 15.1 Food convenience and safety (continued).

Antecedent Food Practice	Contemporary or Emergent Practice	Safety Measures Available
Use of salted, cured, and fermented foods	Reduced consumption of such foods because of concerns about sodium and blood pressure, nitrites and cancer, and interest in fresh and refrigerated foods.	Education about microbiological safety conferred by these food practices Steps to be taken if alternative methods of preservation and storage used

consumption. Sampling requires definition of the population to be analysed and the acquisition of a representative sample (Australian Standard 1766.4 1987). Factors to be considered when sampling include the physical nature of the food—liquid foods can be mixed, while solid foods are likely to be more heterogeneous—and the number of samples that can be analysed cost effectively. The food should not be additionally contaminated during sampling, which should be performed using aseptic techniques. The samples should be transported to the laboratory in chilled containers to avoid additional microbial growth, which is a risk if the sample is not stable at ambient temperatures. Microbiological criteria for foods are published by Food Standards Australia and New Zealand (formerly Australia New Zealand Food Authority; ANZFA 1992), World Health Organization (WHO), Food and Agriculture Organisation (FAO), International Commission on the Microbiological Specification for Foods (ICMSF), and international trade organisations such as International Dairy Federation (IDF).

The microbial quality of food is most frequently assessed by enumerating microorganisms. Viable bacteria, both pathogenic and non-pathogenic, are counted using a variety of non-selective, selective, and differential culture techniques. The microbial analysis of food may be conducted to assess the overall microbial quality and/or indicators of faecal contamination or poor food handling practices, or to enumerate specific pathogens if a potential risk is identified. The microbial quality is frequently assessed by determining the 'total' number of bacteria per gram of food. This is achieved by macerating the food in a sterile diluent and plating a known volume of the suspension of the food onto a non-selective agar (for example, plate count agar). The inoculated agar plate is then incubated for a specified time (for example, 24 hours) aerobically at temperature (normally 30 or 35°C) that permits the growth of mesophilic bacteria. Following incubation, the number of colonies that appear on the plate is counted and the count reported as a standard plate count (SPC) in colony forming units per gram or millilitre of food. It should be recognised, however, that this count only recovers organisms capable of growth under the imposed culture conditions. The mesophilic SPC is initially used to assess microbial quality since many of the food-borne pathogens are mesophiles. A high mesophilic count suggests that the food may have been exposed to conditions that have permitted significant growth of mesophiles, increasing the risk that pathogens may be present. A high SPC requires further investigation to determine if pathogens are present. The contamination of food by organisms of faecal origin is commonly assessed by enumerating faecal indicator organisms; for example, *E. coli* or enterococci. Methods for the analysis of the microbial content of specific foods are published by Standards Australia, the International Commission on Microbiological Specification for Foods (ICMSF 1988), and various industry peak bodies.

ICMSF (1986) details 15 'cases' where the sampling plan changes in relation to the identified hazard (spoilage or hygiene indicator organisms or known pathogens of varying severity and spread), and the conditions that may increase (for example, inappropriate storage) or decrease (for example, chill storage) the hazard. The sampling plan interprets the influence of the number of samples analysed (n), the number of samples failing (c), the adopted criteria (m), and acceptance or rejection of the food. Two types of plan are contained within the 15 cases:

- Two class attribute plans—here the results are divided into two groups: those acceptable and below the microbiological criteria (count) and those that are unacceptable (c). It should be noted that 'c' can equal zero, for example, *Salmonella* must be absent from all samples tested and the stringency of the plan varies with values of 'n' and 'c' adopted.
- Three class attribute plans—these comprise three quality divisions: acceptable; marginally acceptable; and unacceptable. In addition to 'm', this plan includes the term 'M', which is the count that causes rejection of the food. Thus samples recording counts <m are acceptable, counts >m but = or <M are marginally acceptable and samples >M cause rejection of the food.

Box 15.2 Australian Food Standards Code (AFSC) application of sampling plans

The code specifies the analytical methods (*AS1766*) and the sampling plan that should be used, for a variety of foods, to determine compliance with the microbiological criteria specified in the code.

Examples of Two Class sampling plans within the Australian Food Standard Code are:

Food type	Organism of concern	Microbiological limit (m)	n	c
Cheddar cheese	E. coli	ND in 0.01g	5	1
Liquid egg	Salmonella	ND in 25 g	5	0
Desiccated coconut	Salmonella	ND in 25 g	10	0
Infant formula	Salmonella	ND in 25g	30	0

ND, not detected

It can be seen that the stringency of the sampling plans increases from cheese to infant formula as the hazard and risk to the consumer increases. Liquid egg is used in bakery products and receives further heat treatment, which may reduce the risk, whereas desiccated coconut is often used as a topping and may receive no additional treatment, which might reduce the hazard prior to consumption. Infants represent a susceptible population that requires additional protection from the identified hazard.

Examples of Three class sampling plans in the AFSC:

Food type	Organism of concern	Microbiological limit (m)	Microbiological limit (M)	n	c
Pasteurised milk	SPC	5×10^4	1×10^5	5	1
	Coliforms	1	10	5	1
Ice cream	SPC	5×10^4	2.5×10^5	5	2
	Coliforms	100	1000	5	2

The inclusion of wholly acceptable (0 to m), marginally acceptable (m to M) and unacceptable (>M) criteria within the Three Class sampling plan requires that c cannot be equal to 0. This plan may be used as an internal quality control measure during food processing since it can signal when a process is deviating from specification and requires corrective action.

The Australian Food Standards Code adopts both two and three class attribute plans to ensure product safety (see box 15.2).

Sampling and analysis of foods to determine microbiological safety have a number of disadvantages. Traditional microbiological culture techniques require significant incubation times, and often perishable food is released before the results of tests are available, which then become of largely historical value in terms of past process performance and product quality. The development of rapid microbiological methods for the identification and enumeration of organisms in foods is an ongoing research and development objective. Furthermore, it has long been recognised that microbiological testing cannot ensure total food safety; there is always a statistical probability that some food will be accepted as 'safe' that should have been rejected and vice versa. This probability is described by an operating curve for the specific sampling plan. Over the last 25 years there has been a growing recognition that the production and processing of foods should ideally be quality controlled throughout primary production, manufacture, and distribution to point of sale. This has led to the widespread application of the Hazard Analysis Critical Control Point technique (HACCP).

Hazard analysis critical control point technique

The Pillsbury Company, the National Aeronautics and Space Administration (NASA), and the US Army Research Laboratories jointly developed the HACCP technique in 1974. It has since been widely adopted by

Australian food manufacturers as a method of controlling the safety of food and, more recently, it has been promoted within the food service industry (restaurants, delicatessens, and canteens).

HACCP is a method of managing risk. It is site specific, and has some key definitions:

- Hazard—a biological, chemical or physical property that may cause the food to be unsafe for consumption.
- Critical control point (CCP)—a point step or procedure at which control can be exerted and a food safety hazard can be prevented, eliminated, or reduced to acceptable levels.
- Critical limit—a criterion that must be met at each CCP, for example, a specific pH value or temperature.
- Corrective action—applied at or to the CCP when there is a deviation from the critical limit.
- Monitoring—the CCP must be monitored using a planned sequence of observations or measurements to assess whether the CCP is under control; accurate records must be maintained for future verification that the CCP was always under control.

There are seven widely recognised principles to HACCP:

1. Identify the hazard(s). This requires formation of a multidisciplinary team consisting of members with an intimate knowledge of the product and process, and experience in hazard identification, risk assessment, and process control. They will describe the food, its method of distribution, intended use, and consumer group. They produce and verify a flow diagram (see box 15.3) of the production process. Most importantly they conduct the hazard analysis.
2. Identify the critical control point. The hazard analysis should enable identification of the CCP, such as ensuring the correct time and temperatures within the process.
3. Establish critical limits for each CCP. For example, adjusting the pH to below 4.5 to prevent botulinum toxin production, or ensuring correct time and temperatures during the pasteurisation of milk (not less than 72°C held for not less than 15 seconds).
4. Establish a monitoring programme and procedures. This is to ensure control of the process is maintained using the results of the monitoring programme.
5. Establish the nature of corrective action. This should include identifying who has the responsibility for undertaking the action.
6. Establish effective record keeping. This is to ensure that the HACCP system is properly documented.
7. Establish procedures verifying that the HACCP system is working correctly. This includes reviewing the performance of the system and conducting verification inspections and producing verification reports.

It should be noted that there is still a requirement for understanding risks associated with food production, processing, and serving. This is obtained via food education, adherence to good manufacturing practice, and the maintenance of good food hygiene and handling practices. These essential requirements for the provision of safe and hygienic food are not replaced by the HACCP technique.

Food-borne illness

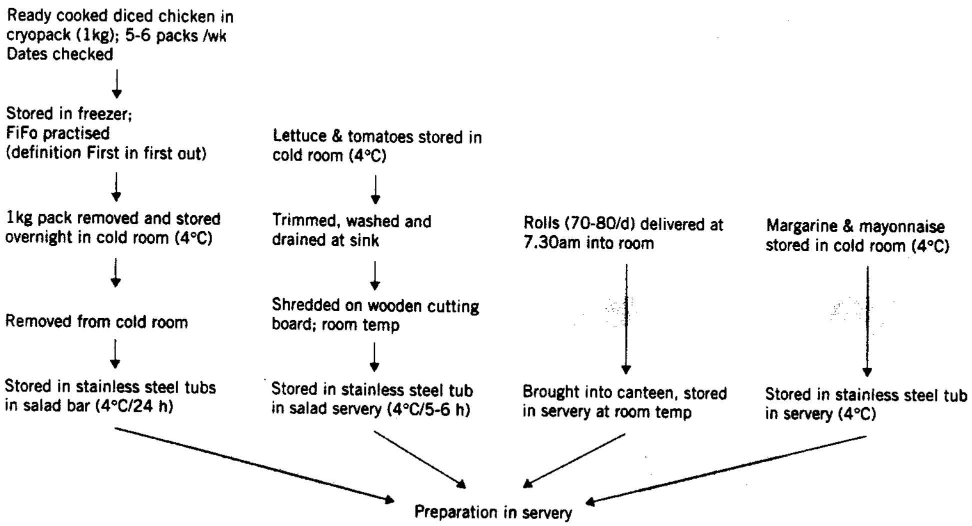
In Australia and New Zealand a number of outbreaks of food-borne illness occur each year and the frequency of these outbreaks may be increasing. However, the ability to link food-borne pathogens with human illness is made difficult by the fact that many

Box 15.3 Food safety plans—hazard analysis critical control point technique in school canteens

In 1997 a study was conducted on the potential application of food safety plans in school canteens in South Australia. Below is an example of how this technique might be applied in these environments.

Flow diagram

Chicken Salad Sandwich



Hazard analysis

The identified hazard is microbiological, associated with handling and storage of the sandwich resulting in potential contamination and growth of food poisoning organisms. The specific type of organism is dependent upon the sandwich filling, but could include Salmonellae, *Staphylococcus aureus*, *Listeria monocytogenes*, *Campylobacter*, *Escherichia coli*, rotavirus, Norwalk virus, and other viral agents associated with gastrointestinal illness). The hazard is associated with:

- contamination of the sandwich during handling and via contact with surfaces and utensils, which may result in cross contamination
- the temperature of storage of the sandwich following preparation potentially resulting in the growth of pathogenic bacteria.

Critical Control Points (CCPs)

1. Personal hygiene of the food handlers. This would include the use of clean protective clothing, hairnets, and hats, along with correct hand-washing procedures using

soap and hot running water (dried preferably using disposable paper towels) and the correct use of gloves, which are changed regularly between products and following contact with non-food contact surfaces and the body, for example, hair, nose, or ear.

2. Utensils and contact surfaces. This entails double sink washing with a final hot water rinse (>80°C; providing suitable gloves or racks are available) followed by air drying for utensils or the use of a dishwasher. Chopping boards, which are of suitable material—such as polypropylene (colour coded for various food products), glass, or wood—and which are not etched, cracked, or scored. The boards should be washed as above, while food-contact surfaces should be washed with warm water and a proprietary detergent, sanitised with a proprietary sanitiser.
4. Storage of the finished sandwich. Irrespective of ambient temperature, the sandwich should be stored at < 4.0°C between preparation and consumption.

Monitoring and corrective action

1. Personal hygiene—Monitoring is through observation by canteen manager, however, compliance would be assisted by the establishment of a formal training programme for volunteers, which would culminate in a written undertaking that they have understood and agree to comply to the personal hygiene requirements.
   - Corrective action—discussion of knowledge and attitudes with canteen manager to identify training needs.
2. Washing of utensils and/or chopping boards—A designated person should oversee a schedule of cleaning operations, and measure and record water temperatures. Food-contact surfaces should be inspected for physical damage.
   - Corrective action—suitable adjustment of rinse water temperature, the replacement of damaged boards, and/or the repair of surfaces.
3. Refrigeration and storage of raw and finished product—A designated person should measure and record the refrigerator temperature daily. Also important is stock management, including rotation and the recording of date codes.
   - Corrective action—adjustment of the refrigerator thermostat to obtain internal temperature of 4°C.

cases of food-borne illness remain unreported (see chapter 13). Table 15.2 lists a range of the more common potential food-borne pathogens. Students are referred to texts such as Hocking (2003) for details of individual organisms. To this list could be added novel agents such as the prion that causes Bovine Spongiform Encephalitis (BSE), but it is not strictly infectious and has yet to be found in Australia and New Zealand. The factors contributing to the outbreak of food-borne disease are presented in table 15.3.

Box 15.4 illustrates the type of investigation that is often required to demonstrate that a food may have been the source of a pathogen that caused human illness, but leaves open the question of what the ultimate source of the pathogen might have been.

Food Standards Australia New Zealand (FSANZ) is a statutory body that sets the

Table 15.2 Examples of food-borne pathogens found in Australia and New Zealand.

Pathogenic Bacteria	Pathogenic Bacteria
Salmonella spp.	**Enterovirulent Escherichia coli Group (EEC Group) (continued)**
Clostridium botulinum	*Escherichia coli*—enteropathogenic (EPEC)
Staphylococcus aureus	*Escherichia coli*—enterohemorrhagic (EHEC/STEC/VTEC)
Campylobacter jejuni	*Escherichia coli*—enteroinvasive (EIEC)
Yersinia enterocolitica	**Parasitic Protozoa**
Yersinia pseudotuberculosis	*Giardia Lamblia*
Listeria monocytogenes	*Cryptosporidium parvum*
Vibrio cholerae non-O1	*Cyclospora cayetanensis*
Vibrio parahaemolyticus and other vibrios	**Viruses**
Clostridium perfringens	Hepatitis A virus
Bacillus cereus	Hepatitis E virus
Shigella spp.	Rotavirus
Enterovirulent Escherichia coli Group (EEC Group)	Noroviruses
Escherichia coli—enterotoxigenic (ETEC)	

Adapted from: Briggs (1997); Miller Jones (1998); ANZFA (1996).

Table 15.3 Factors contributing to food-borne illness and processes that may be critical control points.

Contributing Factor	Potential problems if process is not properly controlled
Inadequate cooking	Internal temperature insufficient to kill most disease-causing bacteria
Improper cooling	Maintenance of food at temperatures and for times that permit the rapid growth of disease causing bacteria
Inadequate refrigeration	Not maintaining foods at temperatures at or below 4°C, causing bacteria to grow
Inadequate thawing	Food thawed at too high a temperature, which may result in growth of disease causing bacteria, particularly on the surface
Inadequate re-heating	Internal temperatures that are insufficient to kill or prevent the growth of disease-causing bacteria

Cont.

Table 15.3 Factors contributing to food-borne illness and processes that may be critical control points (continued).

Contributing Factor	Potential problems if process is not properly controlled
Inadequate hot holding	Holding of foods at temperatures too low (<60°C) to prevent the growth of disease-causing bacteria
Personal hygiene	Contamination of food with disease causing bacteria from hands, nose, ears, hair, faeces, and pet animals
Cross contamination	Contamination of ready-to-eat food with bacteria from raw foods such as meat and poultry via handling, utensils, and work surfaces
Surfaces and utensils	Possible bacterial contamination of food by improperly cleaned utensils and surface

Box 15.4 A food-borne disease investigation

Salmonella infection is a notifiable disease in Australia. In February 1999, an apparent cluster of cases of *Salmonella* Typhimurium phage type 135a was detected by the Communicable Disease Control Branch in South Australia. An investigation was launched with detailed food histories taken from notified cases. These interviews were conducted to generate hypotheses to identify foods that may have caused the outbreak. Communicable disease control units in other states were asked if they had seen an increase in cases (none had noted an increase).

For the purposes of the investigation, a 'case' was defined as a case of *Salmonella* Typhimurium phage type 135a infection notified from 1 January 1999, and information collected on who was the first case notified in his or her household. To 31 May 1999 a total of 502 cases met the case definition for the investigation. Onset of disease for the first case was on 12 January, and there was a rapid increase in the numbers of cases with onset of symptoms over a period of 3 weeks from 1 February 1999.

Food consumption histories were obtained from twenty-six cases in wide-ranging hypothesis-generating interviews. These interviews consisted of enquiry about the foods eaten at any time in the 10 days before illness. Cases reported they had collectively eaten several hundred different foods. A case-control study was conducted to investigate differences in food consumption between cases and controls. The foods recorded in the initial interviews were ranked in order of frequency of consumption by the cases. The most frequently consumed foods were included in a questionnaire for a case-control study that was applied to twenty-four cases and seventy-two controls.

Controls were selected from a database of SA residents who had agreed to participate in health-related surveys. The database, which is based on a random sample of SA residents, contains some 44,000 adults and 5000 children. Three controls per case were selected and matched on age (to 5-year age class), gender, and postcode of residence (the same postcode, or if none were available from the postcode, from the nearest postcode with an available age- and gender-matched control). Potential controls who had suffered from any gastrointestinal symptoms in the previous month were not selected.

In an unmatched analysis, four foods were associated with being a case: orange juice, hot dogs, sandwiches, and chicken nuggets (see also table 15.4).

Table 15.4 Odds ratios for foods significantly associated with being a case.

Food	Odds ratio	95 per cent confidence interval
Orange juice	6.43	1.67–36.04
Hot dogs	5.67	1.17–29.69
Sandwiches	6.53	1.85–23.79
Chicken nuggets	5.42	1.42–21.28

Eighty-five other foods were not significantly associated with illness. Analysis of the risk associated with orange juice revealed differential risks according to brand of juice. Brand A orange juice had an odds ratio of 9.57 for association with infection (unmatched analysis) with a 95 per cent confidence interval of 2.45–39.42. Other orange juices were not significantly associated with infection, except for Brand B orange juice, with an odds ratio of 5.67 for association with infection (unmatched analysis) with a 95 per cent confidence interval of 1.22–27.77. A stratified analysis was made to investigate the possibility of confounding between Brand A and Brand B orange juices. This analysis found a non-significant association between infection and consumption of Brand B orange juice.

A sample of Brand A orange juice, bought from a supermarket on 5 March 1999, tested positive for *Salmonella* Typhimurium phage type 135a. A second sample of Brand A orange and passionfruit juice purchased from a different supermarket on 9 March 1999 also tested positive for *Salmonella* Typhimurium phage type 135a.

The conclusion to this epidemiological investigation was that the most likely source of the outbreak *Salmonella* Typhimurium page type 135a infection was Brand A orange juice. It also illustrated the fact that large numbers of people were probably exposed to this infection, many of whom did not become ill, and there were likely many others who had illness that was never reported or investigated.

Source: South Australian Department of Human Services.

regulatory framework for food standards, including those that pertain to food safety. The Food Standards Code comprises three standards: the general food standards, food product standards, and food safety standards.

In the area of food safety in Australia, the food safety standards are in three sections encompassing: Interpretation and Application; Food Safety Programs, Food Safety Practices and General Requirements; and Food Premises and Equipment. The Australian states and territories have agreed to adopt uniform food safety standards. The food safety standard defines potentially hazardous food and requires that food handlers have the required skills in, and knowledge of, food safety and hygiene commensurate with their work activities. However, they are not required to undertake formal training. The standard also includes requirements for receiving food and time temperature control. It also clearly defines the obligations of food handlers and food businesses with regard to protecting food safety. However, it does not require development of specific food safety plans.

CHEMICAL SAFETY

Naturally occurring toxicants

All foods contain a magnitude of chemicals that occur naturally and some of these are toxic to humans. Some of these compounds have developed in plants as a means of protection. For instance, the potato and the tomato contain toxic alkaloids that protect against pests and/or infections (Miller Jones 1998). Many naturally occurring toxicants remain relatively harmless if foods are prepared properly, not eaten if unripe or discoloured, or eaten in large quantities.

Food contaminants

Foods may contain a number of contaminants that occur as a consequence of human activity. These contaminants may be toxic, especially if excessive quantities are ingested. Pesticides, fertilisers, and pollutants are the most common types of contaminants, although heavy metals like arsenic, cadmium, mercury, and lead that occur naturally may become more concentrated in certain foods with human activity. Filth is also another common food contaminant.

The Australian Total Diet Survey (formerly The Market Basket Survey) published its most recent survey, *The 20th Australian Total Diet Survey*, in January 2003 (www.foodstandards.gov.au). Food consumption patterns (based on a dietary modelling method) are compared with the food residue concentrations and this information can be used to assess any potential risk to health that may be associated with the consumption of these contaminants. Table 15.5 lists some of these contaminants.

One of the dilemmas highlighted by the Belgium dioxin fiasco (see box 15.5), especially for less economically developed countries that may have been importing contaminated food, is the cost of detection. This is because the mass spectrometry-chromatographic requirements are often beyond the resources available, and the technical capacities to perform such analyses are lacking. Thus, it is often the case that food safety measures require international cooperation.

Food allergy or intolerance

The expression that 'one man's food is another man's poison' is very true under certain circumstances. Particular foods may be eaten safely by the vast majority of individuals, but will cause allergies in some.

Table 15.5 Some naturally occurring toxicants and their source foods.

Naturally Occurring Toxicants (and their major food sources)

Enzyme inhibitors (legumes)
Haemagglutinins and lectins (seeds and grain)
Saponions (soybeans, spinach, apples)
Vicine and covicine (broad beans)
Lathyrogens (sweet pea, vetch)
Goitrogens (turnip, broccoli, Brussel sprouts, cabbage, soybeans, pine nuts, peanuts)
Cyanogenic glycosides (almonds, black beans, cassava)

Phenolics
Tannins (bananas, grapes, raisins, spinach, red wine, beer)
Vanillin (vanilla)
Gallic acid (tea, red wine)
Caffeic acid (eggplant, carrot, Brussel sprouts)
Chlorogenic acid (coffee, tea, apples)
Coumarin (herb teas)
Oxalates (spinach, rhubarb, tea)
Phytates (nuts, legumes, whole grains)
Mineralocorticoid stimulators (liquorice)

Alkaloids
Solanine (Potatoes—especially if green)
Tomatine (Tomatoes—especially if green)
Caffeine (coffee, tea, cocoa, cola beverages)
Quinine (tonic water)
Pyrrolizadines (grains)
Nitrates/nitites (celery, cucumber, lettuce, spinach, cabbage, radish, rhubarb)
Oestrogens (soybeans)
Seafood toxins
Ciguatera toxin
Shellfish toxins (PSP, DSP, NSP, ASP)

Scombrotoxin
Tetrodotoxin (pufferfish)
Mycotoxins
Aflatoxins
Ochratoxins
Patulin
Zearalenone

Table 15.6 Some contaminants that may be found in foodstuffs.

Pesticides, Herbicides, Fungicides

Organochlorine pesticides
Aldrin, benzene hexachlorides, chlordane, chlorpropham, DDD, DDT, DDE, dieldrin, endrin, endosulfan, heptachlor, lindane, tetradifon

Organophosphorus pesticides
Azinphos-ethyl, azinphos-methyl, chlorfenvinphos, chlorpyrifos, chlorpyrifos-methyl, diazinon, dichlorvos, dimethoate, dioxathion, ethion, fenitrothion, fenthion, maldison, methamidophos, methidathion, mevinphos, monocrotophos, parathion, parathion-methyl, pirimphos-methyl, prothiophos, trithion

Pyrethroid pesticides
Cyfluthrin, cyhalothrin, cypermethrin, deltamethrin, fenvalerate, flumethrin, permethrin

Fungicides
Chlorothaloil, dicloran, diphenylamine, iprodione, pyocmidone, vinclozolin

Herbicides
2,4-D (2,4-dichlorophenoxyacetic acid), 2,4,5-T (2,4,5-trichlorophenoxyacetic acid), TCDD (2,3,7,8-tetrachlorodibenzo-p-dioxin)

Incidental Contaminants
Antibiotics
Growth promoters (hormones)
DES—diethylstilbestrol (synthetic estrogen)
Fertilisers
Pollutants
PBCs polychlorinated biphenyl
PBB polybrominated biphenyl
Filth
Dirt, cleaning agents, hair, insects, rodent excreta
Packaging
Inks, plasticisers

Food allergies can cause skin irritations or more serious anaphylactic reactions that may result in death. Peanuts are one such potent allergen and trace quantities contaminating foods have become an important cause for food recalls.

Food additives

The intentional addition of chemicals to foods has been practiced for many years, perhaps with salt being one of the first food additives ever used. Food additives can have a variety of purposes including improving the nutritional

Box 15.5 Case study: dioxin in Belgium

The Belgium dioxin food scandal began with traces of dioxin being discovered in chicken meat. Subsequently many countries, including Australia, put a ban on certain foods from Belgium.

From 5 June 1999, the Australian Quarantine Inspection Service (AQIS) implemented a 'hold and test' regime at the border to prevent any potentially contaminated egg, poultry, beef, pork, and diary products from Belgium, France, or the Netherlands from entering Australia.

The Australia New Zealand Food Authority (ANZFA) advised retailers to voluntarily withdraw from supermarket shelves any foods from Belgium suspected of dioxin contamination while discussions were held with importers, overseas authorities, the states and territories, and AQIS. Potentially contaminated imported products included all egg, poultry, and pork products, as well as biscuits, pastries, and sauces produced between 15 January 1999 and 2 June 1999.

The import restrictions and bans remained in place until suppliers could confirm that each imported consignment of food was free of dioxin.

quality of a food, enhancing its palatability and appearance, and extending its shelf life. Consumers display mixed feelings about food additives with many believing food additives cause cancer. In Australia and New Zealand there are tight regulations governing the use of food additives and their use must be declared on the food label (Briggs & Lennard 2002). Provided manufacturers comply with these regulations, food additives should not pose a threat to health and in certain cases may make a food product safer, for example, the addition of salt or acetic acid may inhibit the growth of some microbial pathogens.

NUTRITIONAL SAFETY

Where foods do not contribute a balance of nutrients and other food components—which allow survival, health, and well-being—to the overall diet, they may be regarded as unsafe. In a traditional diet, or one that has been subject to rigorous revision in accordance with scientifically based dietary guidelines, foods which contribute to the cuisine are likely to be safe. However, with experimental food technologies and newer food formulations, the likelihood that foods will be nutritionally unsafe increases.

As with other forms of food safety, food nutritional safety thus depends on appropriate risk analysis and communication, along with monitoring and surveillance.

Australia and New Zealand are members of two international organisations that deal with food safety issues: The Codex Alimentarius, an international system directed towards protecting the health of consumers, making sure food trade practices are fair, and coordinating all food standards work; and the World Trade Organization (WTO), which deals with the worldwide rules of trade between different nations. Its main objective is to ensure that trade flows freely and without incident. The Australian Quarantine and Inspection Service also assists at an international level to improve food safety. It is responsible for protecting Australia against the introduction and spread of foreign pests and disease. It also assists internationally by providing export certification for agricultural produce and other commodities.

Altogether new food formulations are now appearing that present various food safety challenges. Some of these formulations leave out antimicrobial factors previously present in traditional foods (like salt, sugar, nitrites, acid produced on fermentation, herbs, and spices), while others introduce new options for microbial control through the packaging, storage, and cooking systems employed.

One area of uncertainty about risk relates to the increased use of certain ingredients with functional properties where the upper limit of safe intake is not defined. These include: phytosterols in margarines to lower blood cholesterol concentrations; soy protein to increase protein intake; and pre-biotics and pro-biotics to stimulate and favour the growth of particular intestinal microfloral profiles. Dietary modelling—for example with ANZFA's 'DIAMOND' (Dietary Modelling of Nutritional Data) system—may help minimise these risks. In the foreseeable future, people working in food safety are likely to require access to population databases to do with food intake and health indices in order to evaluate risk. Fortunately, the information sciences are allowing such approaches to become realistic.

With the re-evaluation of micronutrients (vitamins and elements), essential fatty acids (n-3 and n-6), and phytonutrients (and, hence, health) will come new waves of food fortification, modulated by risk-benefit and cost-benefit analyses of the health implications. The almost certainly too-low intake of omega-3 (n-3) fatty acids from fish, other seafood, and certain plant foods (such as linseed, rape seed, and soy) is being addressed by adding these fatty acids to various food products. Australia now has a 'Folate-Neural Tube Defect Health Claim' pilot project, where breakfast cereals are allowed to contain more folate than would be normally expected to be found in such items, at a time when good sources of folate, such as liver and yeast, are consumed less often.

ECONOMIC AND POLICY ISSUES IN FOOD SAFETY

The food supply and related health patterns are forever changing, but, at present, are probably changing more rapidly than ever before. These changes are driven by unprecedented advances in technology and transport, and through migration. This dynamic requires a food safety regime that has a short response time.

Animal production is increasingly intense for livestock and poultry, and even through aquaculture. As a consequence, animal health and biosecurity are threatened by new pathogens (which may develop in poorly nourished animals like those with selenium deficiency where viruses may become more pathogenic) and limited ecological barriers to their spread. In recent times, new pathogens in pigs and poultry have contributed to economic crises in Malaysia and Hong Kong respectively, while Newcastle disease in Australian poultry is a perennial threat. Greater cooperation between animal, food, and human-health scientists is required to understand the complex dynamics of potential food-borne disease agents and to protect human consumers.

FOOD RISK, SAFETY, AND THE ENVIRONMENT

The safety of food irradiation is increasingly clear, provided good food handling and manufacturing practices are in place, allowing difficult areas of food microbiological safety to be addressed. Its introduction should add to overall food safety, although education about the technology and what is does to food will remain important during its wider application, beyond commodities like herbs and spices.

Despite the fact that Australia and New Zealand boast two of the safest food supplies in the world, surveys have shown that consumers worry about the food they eat. In Australia, consumer confidence in food has been challenged by a number of developments, particularly food microbiological scares (for example, the cases relating to mettwurst and orange juice in South Australia). However, public anxieties also have arisen around new technological developments to increase crop yield that may have long-term health consequences, for example, genetically modified (GM) foods. Attempts to 'industrialise' the food supply and increase yields almost inevitably result in a more complex food system. Such complexity often leads to unknown possibilities and increased uncertainties, which are perceived as risks. As perceived risks rise, public trust decreases (see chapter 9). Consumers often feel they have put their trust, and health, in the hands of an abstract and increasingly unfamiliar system. This degree of unfamiliarity heightens perceptions of risk and danger as consumers feel increasingly that the quality of the food they eat is not under their control.

It can be tempting to dismiss public concern or anxiety about risk as irrational or unfounded. However, food regulators and food industry groups in various parts of the

Box 15.6 Case study on genetically modified foods

Over the past 5 years the public has been increasingly exposed to information about Genetically Modified (GM) food. In order to better manage the increasing number of applications from biotechnology companies to research and release GM products in Australia, in 2000 the Office of the Gene Technology Regulator was established. Despite increased and tighter legislation of the GM area, however, there continues to be a polarisation of opinions about the safety of GM products, especially GM foods, and the wisdom of commercialisation.

The case for each side of the debate can be summarised as follows. Supporters of GM believe that genetic modification of food is not new. For thousands of years, they say, humans have modified the foods they eat to increase production by mixing genes from different varieties of cereals, cross breeding cattle, and using bacteria in the production of foods like cheese and beer. The newer forms of GM, it is said, are really no different and pose no health threat. Furthermore, modern GM techniques allow a much more accurate transfer of genetic information with much more reliable results. Some products that arise from current GM technology are insect-resistant cereals (such as bt corn) and insecticide-resistant plants (such as 'Round-up Ready' soy).

GM crops already exist in the cotton growing industry and bt cotton is regarded by supporters of GM as proof that GM products can be grown successfully and safely in Australia. Lastly, supporters believe that the GM food crops produced for commercialisation have been adequately tested and proven to be safe. Supporters believe that Australia and New Zealand should take advantage of major scientific and economic possibilities, which will enhance the food supply and overall quality of life.

Opponents of GM food, on the other hand, argue that there is no human history of the type of GM technology available today, where genes from entirely different species can be combined (for example, bacteria–plant or plant–fish). This is very different, they say, from cross-breeding varieties within the same species group (such as cow–cow, corn–corn, or even wheat–barley). Opponents also question the long-term effects of plants engineered with, for example, insecticidal properties on the local environments, where innocuous—or even beneficial—insect life might be destroyed, thereby endangering larger ecological niches (such as birds and larger animals). Opponents also doubt the degree of testing of GM foods. It is believed that field tests of crops do not replicate the conditions likely during full production of GM crops. Opponents also state that few, if any, GM foods have been tested on human populations. Lastly, opponents point to other processes or products, which were considered harmless at the time, but are now believed to be dangerous. Examples include DTT and asbestos. Opponents believe that the 'precautionary principle' should be applied to GM foods. This states that 'when an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some of the cause-and-effect relationships are not fully established scientifically'. In other words, because there are a number of unanswered questions, say opponents, GM food testing and commercialisation should be stalled until we have better information.

Needless to say, both supporters and opponents of GM foods have ample evidence to support their different cases. Over the past 5 years, numerous debates have been had in medical, health, and environment-related journals and conferences about GM foods. Often papers and opinions are positioned back-to-back putting opposite views. Whether this debate has enlightened or confused the community is hard to say. For our purpose here, however, we can examine the GM debate as an example of the ways in which safety, risk, and danger has been reconfigured and are now played out. For example, the public concerns about the safety of GM foods to human health are not about short-term or acute toxicity; no one appears to believe that GM foods pose acute threats to health or will cause immediate food poisoning. On the contrary, the concerns are about chronic exposure, and uncertainty of adequate testing of long-term consequences to human health and the environment. Moreover, concerns have grown regardless of advice from expert committees in Australia, New Zealand, and overseas suggesting that GM foods are not harmful. Thus, the GM case demonstrates profound public disbelief in authority and expertise. We are then dealing with new perceptions of risk and safety.

Box 15.7 Case study on obesity

To further examine the changing nature of risk we will look at another case study concerning the food supply and the environment. Over the past 2 years, there has been increasing concern about the number of Australian and New Zealand adults and children who are too heavy for their health's sake. Data from recent surveys show that the number of overweight or obese children has doubled over the past 10 years. Similarly, over the same period men and women have become fatter. There is wide agreement that the causes of this are multifactorial: diet, exercise, and mode of living all have a role.

In order to bring these causes together, however, experts are now discussing the ways in which we now live in environments that allow us ready access to high-energy food (and that deny easy access to exercise) and the technologies that encourage us to be sedate (such as TV at home and computers at work). The term 'obesogenic' (that is, causing obesity) is now increasingly used to describe these environments. Moreover, obesogenic environments are regarded as toxic to human health. The term 'toxic' here is not used to represent the presence of a poison or toxin, rather, it is used to denote that under these circumstances, and exposed to these conditions, human health is likely to suffer. It is therefore a different consideration of the term toxicity, and carries with it altered ideas about what is a risky and what is a safe environment. What we can see, therefore, is that environmental health is having to accommodate different understandings of risk. Not only are we concerned with short-term risks—for example, through the questionable microbial quality of food—but we must confront the consequences of long-term, chronic risk, and a fear of the unknown.

world have all learned to their cost that public perceptions of food risk can have a marked effect on confidence in food purchases and food legislation, and trust in food industry practices. Moreover, public fears can sometimes be confirmed. For many years, the UK government attempted to prove to a suspicious public that Bovine Spongiform Encephalopathy (BSE or 'mad cow' disease) was strictly an animal disease and could not pose any threats to human health. The government later had to announce that there was indeed a possibility that the growing incidence of a variant of Cruzfeld Jacob Disease (vCJD, a human form of BSE) could be linked to 'mad cow' disease. This was considered to be a crisis point for the UK food supply. However, this concern did not stop at the UK borders. While the number of people actually affected by vCJD is very small (less than 100), public anxiety around the world about BSE is vast. Governments in many countries have moved to counter any possible importation of food products that may contain contaminated beef. The occurrence of BSE in Japan recently served to heighten anxieties of a possible outbreak in Australia. A strict code of country accreditation has recently been introduced in Australia and New Zealand to quell growing consumer unrest about meat imports.

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