Appendix C: Technical Annex

CONTENTS

1. Purpose Of This Document

Egg producers need to keep their eggs safe to eat in order to stay in business. If there is a problem associated with their eggs this may result in:

- loss of earnings;
- legal action;
- unemployment;
- loss of reputation; and
- loss of business.

In many overseas countries food-borne illnesses have been directly related to consumption of raw eggs. Whilst the corresponding figures for eggs in New Zealand are much lower there is no room for complacency. Industry professionals have a legal and moral responsibility to:

- protect their customers;
- provide safe food; and
- protect their business and the reputation of the industry.

Remember that prevention is better than the cure. The Animal Products Act 1999 requires those who process animal products to have a **risk management programme,** based on HACCP (Hazard Analysis and Critical Control Point) principles, to identify and control hazards and other risk factors so that their products are **fit for their intended purpose**.

This technical annex has been produced by MAF Food Assurance Authority in conjunction with the Egg Producers Federation of NZ Inc.

The annex will provide scientific and technical information, from both New Zealand and overseas, to facilitate the updating of the industry agreed Code of Practice so that it:

- will help egg producers to develop their risk management programmes;
- is based on the principles of HACCP;
- identifies the following hazards and other risk factors associated with the production, grading and packing of whole shell eggs and any by-products;
  - ☐ hazards to human health,
  - ☐ hazards to animal health,
  - ☐ risks to wholesomeness, and
  - ☐ risks from false or misleading labelling.
- covers any new or emerging hazards that should be addressed; and
- discusses possible control measures for the identified hazards and other risk factors.

The New Zealand commercial poultry flock (including chickens, hens, turkeys and ducks) has a unique animal health status superior to that in other countries. This sometimes makes extrapolation of overseas findings and requirements inappropriate to the New Zealand situation.

A significant portion of New Zealand’s eggs are produced under one of two existing Codes of Practice:

- A supermarket-required Code of Practice has been available since 1998.
- Commercial egg producers with over 100 birds have had access to an industry agreed Code of Practice since June 1993.

This means that many of the hazards and other risk factors that are identified in this annex are already subject to suitable controls. These existing Codes of Practice give guidelines on currently accepted practices but are not necessarily based on the principles of HACCP – so it is not always obvious why some practices are recommended.

Key Messages to New Zealand Egg Producers:

Key points for the reader to note are shown in boxes in this annex as shown here.

2. The New Zealand Egg Production Industry

No table eggs are imported into New Zealand because MAF imposes strict quarantine regulations to protect the superior health status of the New Zealand poultry flocks. There are some exports from New Zealand of:

- specialist eggs to niche markets overseas, and
- fertile eggs and day old chicks to the Pacific (PIANZ, 2001).

In the late 1980s there were over 450 egg producers. At this time price and production controls in the egg industry were abolished, and the New Zealand Poultry Board was dis-established. This change was followed by a dramatic reduction in returns to producers, though this was not always matched by a reduction in retail egg prices. Deregulation changed the relationship and relative profitability of producers and egg wholesalers. Many producers now sell direct to the wholesale and retail trade rather than through co-operatives or other organisations.

Poor profitability for egg producers during 1994 and 1995 resulted in a reduced egg supply as producers went out of business. By mid 1996 increased demand for eggs led to the advent of higher wholesale egg prices, though this was short lived. The cyclical nature of the egg industry will continue. The last decade has also seen a wider choice of egg types available from standard white to brown, to whole-grain, vegetarian, omega enriched, barn, and free range eggs.

In 1998 New Zealand’s estimated 2.6 million laying hens produced close to 65 million dozen eggs. Over 85% of eggs are sold as table eggs within the domestic market, with the remainder used in the baking and catering industries. Total egg production has remained relatively static for the past decade, with per capita consumption around 200 eggs per person annually. Most eggs produced in New Zealand are from caged hens. Free range and barn egg production account for around 7% of the total.

The Egg Producers Federation of New Zealand has estimated that in the year 2000 there were around 130 commercial egg producers, with the largest 20 producers accounting for over 50% of total production. Since deregulation in the late 1980’s the number of commercial egg producers has declined rapidly. This decline is likely to continue with further restructuring of the industry hastened by the introduction of the Animal Products Act 1999.

3. Foodborne Illness

Key Messages to New Zealand Egg Producers:

The most important reason for having a risk management programme is to help avoid making your customers sick, and to protect your business.

3.1 New Zealand Situation – All Foods

In New Zealand, 1998 and 1999 were record years for salmonellosis from all food types. In 1998, 2069 cases were notified (a rise of 77% from 1997 figures) and in 1999, 2079 cases were notified. In the year 2000 there was a decrease down to 1802 cases of Salmonellosis (ESR, 2000). The following table gives the figures for the years 1995 to 2000.

Table 1: Total *Salmonella* Cases By Year In New Zealand[1]:

Year	Total Cases	Rate per 100,000 people (Crude rate based on 1996 Census Population figures)
1995	1334	36.9
1996	1140	31.5
1997	1169	32.3
1998	2069	57.2
1999	2079	57.5
2000	1802	49.8
2001	2275[2]	52.4

Salmonella Typhimurium 160 has emerged as a major source of human gastroenteritis in New Zealand over the last three years. No human cases were identified in New Zealand before 1998. One case was identified in 1998 and one in 1999 before case numbers began to increase steeply from June 2000 onward. *Salmonella* Typhimurium 160 was isolated in one-third of all human Salmonella cases in the year to November 2001. During November 2001, *Salmonella* Typhimurium 160 accounted for almost one-half (47 percent) of all cases (MOH, 2001).

While *Salmonella* Typhimurium 160 was initially limited to one geographic area of the country, the locations of isolation have now spread throughout the country. (Nicol, unknown).

A large number of bird deaths, mainly in sparrows, coincided with the increase in *Salmonella* Typhimurium 160 from humans. The affected birds died quickly from acute septicemia, with no evidence of enteritis. *Salmonella* Typhimurium 160 has also recently been isolated from cats, dogs, sheep, cattle and horses and the poultry environment (Nicol, unknown).

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[1] Data provided by ESR.
[2] Year to December 14

Table 2: Total Number Of *Salmonella* Outbreaks By Year In New Zealand[3]:

Year	Total number of outbreaks	Note
1997	108	Information only from July 1997
1998	313	
1999	361	
2000	289	

Large numbers of sparrow deaths in Canterbury during 2000 were attributed to *Salmonella* Typhimurium 160 infection. Not all birds which get the illness die -- some will remain well and can excrete the bacteria for weeks. The disease can transfer to humans through direct hand contact with bird faeces, eating food with contaminated hands, preparing food with contaminated hands, and contact with infected animals (particularly their faeces). Careful hand hygiene is recommended as a precaution (MOH, 2001).

A national study into an outbreak of illness caused by *Salmonella* Typhimurium phage type 160 (STM160) identified the following risk factors: contact with an individual with diarrhoea in the previous month, or contact with wild birds or their droppings (sometimes through drinking untreated water from domestic roof-collected rainwater supplies). Cases were over four times more likely to have had contact with another individual with diarrhoea or vomiting in the 28 days before they became ill. People who caught salmonella infection were 30 times more likely than well people to have touched wild birds within the three days before the onset of their illness. Some cases had drunk untreated water from domestic roof-collected rainwater supplies in the three days before they became ill. STM160 was found in four of the eight water supplies tested. As STM160 is carried in the gut of birds there is a risk their droppings may contaminate untreated roof water supplies. Eating raw eggs in products like eggnog, raw cake mix or mousse was not associated with STM160 infection but still carries food safety risks and is not recommended (MOH, 2001).

3.2 New Zealand Situation - Specific to eggs[4]:

Table 3: Total *Salmonella* Outbreaks In New Zealand Due To Eggs/Egg Products

Year	Total number of outbreaks	Suspected Source
1995	0	
1996	0	
1997	0	
1998	2	Free range eggs and duck eggs
1999	2	Free range eggs
2000	0	

As part of an outbreak investigation 180 egg samples from Auckland (a total of 918 eggs) were analysed. These were the same brand and purchased from the same supermarkets as those eaten by cases reporting raw egg consumption. *Salmonella* Typhimurium 160 was not found on the surface or inside these eggs. However, other salmonella bacteria were identified on the outside of some eggs (MOH, 2001).

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[3] Data provided by ESR.
[4] Data provided by ESR.

Key Messages to New Zealand Egg Producers:

The above table shows that few outbreaks have definitely been linked to eggs. It must however be remembered that in many instances it is impossible to determine the food vehicle responsible for an outbreak so **there is no room for complacency**.

3.3 Overseas Situation

New Zealand's rates of notified Salmonellosis are compared with those in other countries in the following table.

Table 4: Rates of Notified Salmonellosis per 100 000 People

	New Zealand5	Australia	US	Canada	England and Wales*
1995	36.9	32.65	17.66	21.80	56.78
1996	31.5	31.82	17.15	22.20	56.14
1997	32.3	37.8	15.66	20.10	63.14
1998	57.2	41.07	16.17	23.30	45.96
1999	57.5	38.64			33.96
2000	49.8	31.72			28.75

*Unofficial rates calculated from incidence data from
http://www.phls.co.uk/facts/Gastro/Salmonella/salm.htm
and population data from: http://www.visitbritain.com/facts_figures/pop.htm

Numerous cases and outbreaks of foodborne illness world-wide have been attributed to the consumption of eggs or egg products.

3.3.1 UK Situation

From 1981 to 1991 the UK had more than a 170% rise in the number of reported cases of *Salmonella* in humans. This was mainly due to an increase in infections due to *Salmonella* Enteritidis. Infections in Northern Ireland have dropped since 1987 when the industry improved control of *Salmonella* Enteritidis in their poultry flock (ACMSF, 1993).

Between 1989 and 1991 the Communicable Disease Surveillance Centre received reports of 2767 outbreaks of foodborne infections due to *Salmonella* Enteritidis in England and Wales which were attributed to eggs or foods containing eggs, but not pasteurised egg (ACMSF, 1993). In the years from 1993 to 1998, 41% of the UK's foodborne outbreaks were caused by *Salmonella* Enteritidis. A variety of other *Salmonella* serotypes including Typhimurium accounted for a further 10% of foodborne illnesses. (WHO, 2001). 10% of all outbreaks were associated with the consumption of eggs.

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[5] Figures are from Table 1 on page C-4.

Since the peak in 1997, laboratory-confirmed cases of human salmonellosis have fallen from nearly 36,400 to just under 17,000, a 53% reduction. The Chairman of the ACMSF was reported as saying "There has been a sustained drop in human *Salmonella* cases since 1997. We believe that this reflects a corresponding fall in the levels of *Salmonella* in eggs. There are reasons for believing that these improvements flow from the widespread vaccination of egg laying flocks against *Salmonella* Enteritidis, combined with improved flock hygiene measures." (ACMSF, 2001). Further studies have been recommended to confirm this.

In 1988 Edwina Currie stated that a large part of the UK egg production flock was infected with *Salmonella*. In a talk to the British Veterinary Poultry Association in 1990, the Chief Veterinary Officer, advanced the view that the abandonment of a requirement for 100% Pullorum testing of parent flocks in the mid 1980s allowed *Salmonella* Enteritidis to get a hold in a few parent flocks which spread the infection around commercial layer flocks. This was relevant as *Salmonella* Enteritidis is a group D salmonella with somatic antigens O:1,9,12. These antigens are shared by *Salmonella* Pullorum and *Salmonella* Gallinarum. (Christensen, 2001).

Key Messages to New Zealand Egg Producers:

In New Zealand layer parent flocks are small in number, and, as most are used for export (unlike the UK situation) Pullorum testing is still carried out. About 30% of *Salmonella* Enteritidis positives will react to a Pullorum test, and with a 100% test of parents, some *Salmonella* Enteritidis positive reactors would be expected if a parent flock were infected with *Salmonella* Enteritidis, and could be further investigated. It is vital that Pullorum testing of parent flocks in NZ be maintained, even if they are not used for export supply. (Christensen, 2001).

3.3.2 USA Situation

The *Salmonella* Enteritidis pandemic that begun in the 1980s led to increased illnesses associated with eggs and egg products (Thorns, 2000). During the years 1988-92, *Salmonella* Enteritidis was responsible for the largest number of outbreaks, cases and deaths reported in the USA (Bean *et al.,* 1997).

24.5% of all *Salmonella* isolates are *Salmonella* Enteritidis. The occurrence of *Salmonella* Enteritidis has increased from 1,207 isolates in 1976 to 10,201 in 1995. Outbreaks and sporadic cases of *Salmonella* infections show an association with the consumption of raw or undercooked eggs. 82% of the *Salmonella* Enteritidis outbreaks were attributed to shell eggs. (*Salmonella* Enteritidis Risk Assessment Team, 1998).

The baseline model for shell eggs used in the FSIS's Salmonella Risk Assessment For Shell Eggs (*Salmonella* Enteritidis Risk Assessment Team, 1998) estimated that:

- 46.8 billion eggs are produced in the US per year
- 2.3 million will contain *Salmonella* Enteritidis
- 661,633 human illnesses per year will be related to the consumption of these eggs
- 94% of people will recover without medical care
- 5% visit a physician
- 0.5% are hospitalised
- 0.05% result in death.

Key Messages to New Zealand Egg Producers:

The makers of Meganvac are currently pursuing Egg Layer claims for the product in the USA. Their first target is a claim for protection against *Salmonella* Enteritidis, but *Salmonella* Typhimurium work is also underway and so far successful. (Personal Communication, Christensen, 2001).

3.3.3 European Situation

In Europe, eggs and food containing eggs have been associated with food-borne illness as shown in the Seventh Report on Surveillance of Foodborne Diseases in Europe 1993-98 (WHO, 2001). Some examples are given below but these are by no means exhaustive.

In **Austria**, the foods most frequently involved in mass catering outbreaks reported to the Austrian Salmonella Centre from 1993-1998 were eggs and egg products, foods containing egg, or salads and dressings.

In **Switzerland** over the same period 69% of outbreaks where the causative agent was identified were due to enteric *Salmonella*, 81% of which were *Salmonella* Enteritidis. All but three of the Enteritidis outbreaks were related to consumption of food containing raw or partly cooked eggs.

In the **Netherlands** *Salmonella* Enteritidis is closely followed by *Salmonella* Typhimurium as a causative agent in human cases of Salmonellosis. It is interesting that in the Netherlands, unlike in many other European countries, eggs and egg products are not the most prevalent food vehicle for foodborne disease.

In **Sweden** the situation is better still. Of the 4308 cases of Salmonellosis reported in 1998, all but 452 of these were thought to have been acquired abroad. None of the outbreaks were related back to eggs.

In **Norway** the incidence of salmonellosis infections is at 34.7 per 100,000 people. Of these, 54.3% were due to *Salmonella* Enteritidis and 15.4% due to *Salmonella* Typhimurium with a number of other serotypes making up the rest of the isolations. Of the total, 85-94 % were acquired abroad. Only 0.6% of outbreaks were attributed to eggs.

In **Finland** the incidence of Salmonella infections was quite high at 53.8. Again most of these were acquired abroad. In 1998 *Salmonella* Enteritidis made up over a third of the serotypes isolated with *Salmonella* Typhimurium the next most prevalent. Only 1.1% of outbreaks were attributed to eggs or egg products.

Key Messages to New Zealand Egg Producers:

This section has shown that a number of countries have a problem with food-borne illnesses due to eggs. New Zealand is lucky that its isolation and good biosecurity measures have helped in this regard but **there is no room for complacency**.

4. Biological Hazards

The egg production environment cannot be made sterile, so it is important to understand how eggs can be contaminated, so that this can be minimised throughout the production and packing processes.

Layer hens become infected with bacteria in three main ways:
- by transmission between and within flocks;
- by the consumption of contaminated feed or water;
- through the environment.

Eggs become contaminated by bacteria:
- as the egg is formed - by infection through the ovaries of the layer hen (trans-ovarian) or
- after the egg is formed (during or after lay) – by entering through the shell (trans-shell) (Bruce and Drysdale, 1994).

Trans-Ovarian Infection

Infection of the ovaries can result in transfer of salmonellae to the yolk, while infection of the oviduct can result in contamination of the albumin. Any contamination occurs prior to the formation of the egg shell and shell membranes (Barnhart *et al.*, 1991). Trans-ovarian infection has been associated with *Salmonella* Pullorum, *Salmonella* Gallinarum, and *Salmonella* Enteritidis. The first two species impact on animal health and the third on human health (Stanley and Baquar, 1994).

Prior to the emergence of *Salmonella* Enteritidis, there was a serious outbreak of salmonellosis in Sheffield due to transovarial transmission of *Salmonella* Typhimurium (Phage Type 141) (Chapman *et al*, 1988). *Salmonella* Typhimurium can on rare occasions be transmitted in this fashion (Christensen, 2001).

Although *Salmonella* Enteritidis infections via the transovarial route (in the egg) are important epidemiologically, transmission on the outside of the egg is probably numerically more important with SE infected flocks (Christensen, 2001).

Trans-Shell Infection

The bird's intestinal, urinary and reproductive tracts share a common opening so the outside surface of the newly formed egg is contaminated with a variety of enteric microorganisms. This is the most common route of contamination for salmonellae other than *Salmonella* Enteritidis. (ICMSF, 1998). Pathogenic and spoilage bacteria may also be transferred onto the egg shell by contact with faeces, nesting material, dust, feed, humans etc.

When a healthy hen lays an egg, the hen's bearing (labelled vagina in fig 1) everts beyond the alimentary tract. This protects the emerging egg from faecal contamination. Also, the stretching of the cloacal lining effectively makes the alimentary opening somewhat slit-like further reducing the opportunity for contamination of egg shells. This is why most egg shells in healthy birds are not covered in faeces. If the bird is suffering from enteritis leading to diarrhoea, this arrangement is less effective at preventing shell contamination (Christensen, 2001).

Key Messages to New Zealand Egg Producers:

This means that egg producers need to keep the hens healthy, and any egg-contact surfaces as clean as possible.

Figure 1: Possible Routes of Infection for Salmonellae Into the Hen's Egg

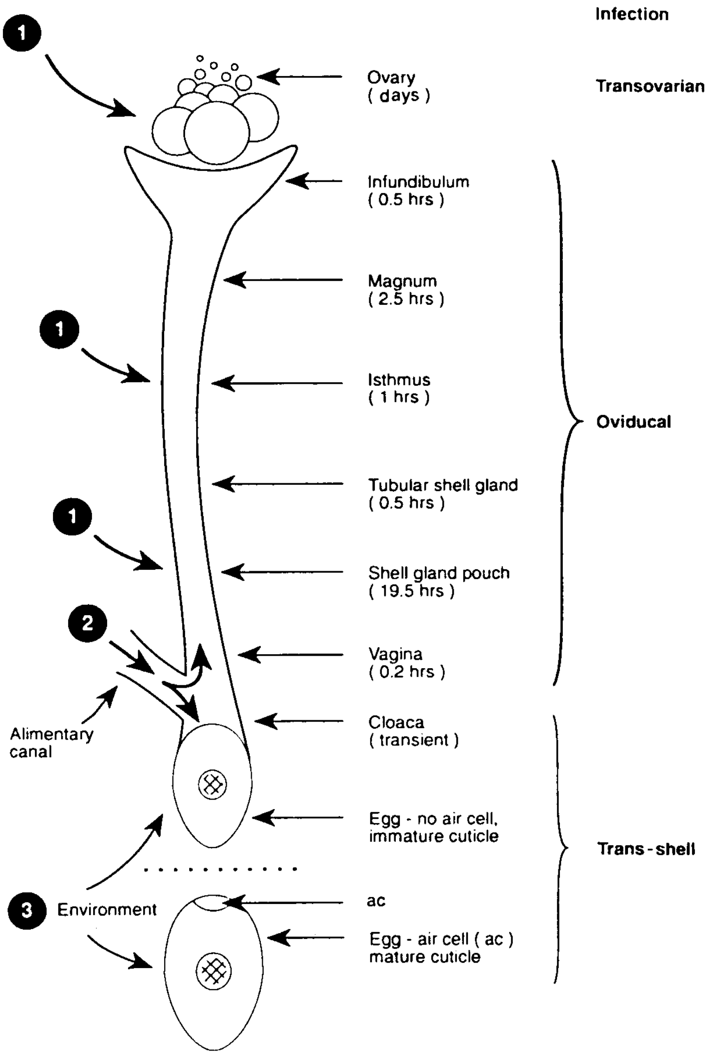

FIGURE 8.5. Possible routes of infection for salmonellae into the hen's egg. **1**, Via the bloodstream and (a) the ovary to the yolk, or (b) through the oviduct wall into the albumen or the membranes before shell formation. **2**, From the intestines via the cloaca up the oviduct or in the cloaca (through the shell). **3**, Through the shell from the environment, especially before the cuticle has matured. (Reproduced by kind permission of Professor R. G. Board.)

Figure ex (Mossel *et al*, 1995)[6]

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[6] Contrary to how it is depicted in the diagram, when an egg is laid, the blunt end comes out first.

It takes approximately 2 weeks for each egg to be formed. This includes secretion of egg white to surround the yolk, followed by formation of the shell membrane and the shell itself. Several of the egg's structures protect it from penetration by microorganisms. In decreasing order of importance they are: cuticle, inner membrane, shell, outer membrane (Lifshitz *et al.*, 1964). Cracks that penetrate the inner membrane enable spoilage and pathogenic bacteria to enter the egg. If the shell is very dirty, microorganisms are likely to penetrate the egg sooner and in greater numbers (Rosser, 1942; Hartung and Stadelman, 1963).

Table 5: Eggs Structures and Their Role in Defence Against Microorganisms

Egg structures	**Description**
Cuticle	• A coating, made largely of protein, on the exterior of the shell that protects the egg for at least 4 days if undamaged. • After 4 days it begins to fail, probably due to cracking as it dries out. • It is permeable to gases. • Fairly resistant to water and detergents but damaged by abrasion.
Shell	• Mostly calcium carbonate. • If undamaged and dry, this will usually keep an egg edible for many months even when stored at room temperature. • Porous, permeable to gases. • Potential for bacteria to invade after cuticle dries up or is washed away.
Outer Coarse Membrane	• This is porous and does not provide a barrier to microbial entry.
Inner Fine Membrane	• This has a fine structure with few pores which delays bacterial entry for a few days. • Also protects against moulds.
Outer Thin White	• Has an alkaline (high) pH that helps to control the growth of most bacteria.
Thick White	• Contains antimicrobial components that make it an antagonistic medium for microbial growth. These include Lysozyme and conalbumin.
Inner Thin White	• Has a high pH.
Chaliziferous Layer	• This is a very dense but very thin layer of albumen. • It ends in the chalaza cords which anchor the yolk in the egg's centre, thus protecting the yolk from damage.
Vitelline membrane	• This encloses the yolk.
Yolk	• As rapidly perishable as milk.
Air chamber (sac)	• Created by evaporation of water reducing the volume of the contents. • Formed between the inner and outer membranes at the blunt end of the egg. • Temperature reduction causes the air sac to contract, resulting in negative pressure. The quicker the drop the greater the pressure differential between the interior and exterior of the egg. As the temperature differential equalises, water and bacteria are aspirated through the shell and become trapped at the surface of the inner membrane.

The table was adapted from information given in ICFMS 1998.
Egg white is also known as Albumen.

Figure 2: Structure of an avian egg

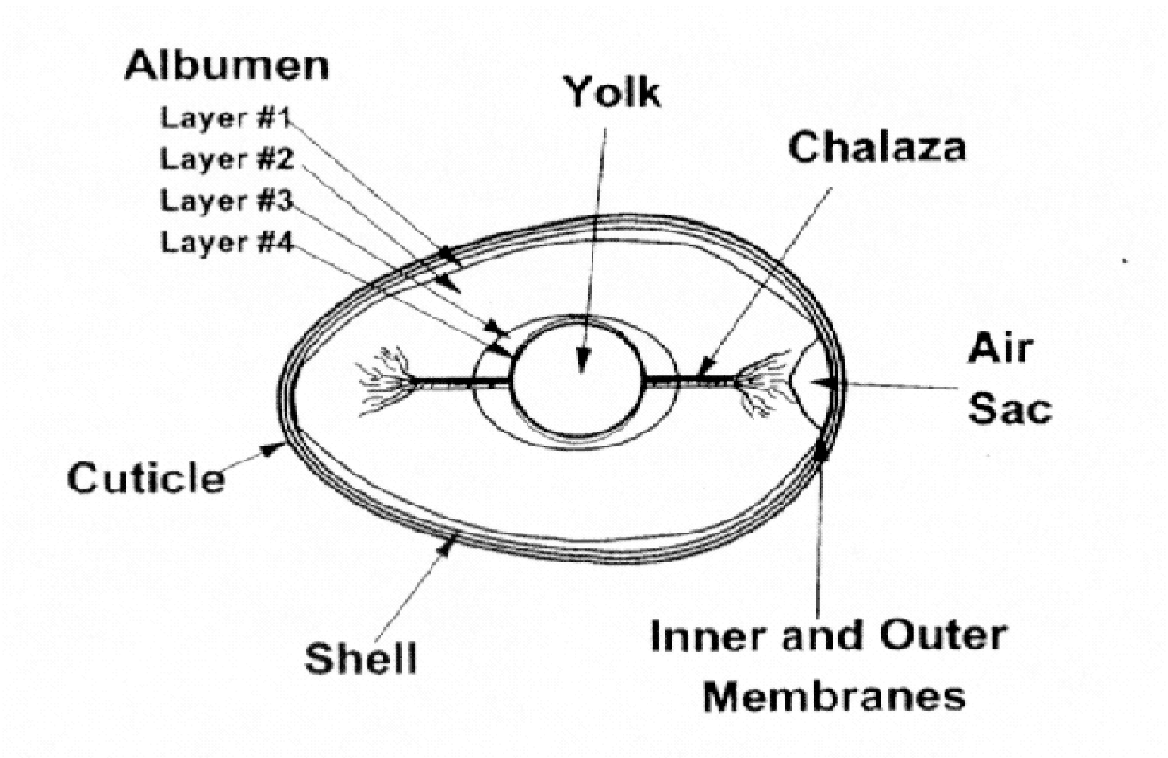

Figure 15.1 Structure of an avian egg.

Figure ex (ICMSF, 1998)

4.1 Salmonella

Key Messages to New Zealand Egg Producers:

Salmonella has caused major problems for the egg industries in the UK and the USA. In both countries the government/and or the industry has introduced new requirements to control this bacteria. The costs to the industry of new labelling, storage, hygiene and vaccination programmes have been significant.

Where a reference has not been specifically given the information on this page has been adapted from the "Bad Bug Book" (USFDA CFSAN, 2000).

Salmonella is a bacterium found in animals, especially in poultry and swine. Environmental sources of the organism include water, soil, insects, factory surfaces, kitchen surfaces, animal faeces, raw meats, raw poultry, and raw seafood, to name only a few.

Salmonellae grow at temperatures between 2 – 45.6°C with optimum growth at 35-37°C. The pH range for growth is 4 to 9.5. Minimum water activity for growth and survival is 0.93. (Canadian Food Inspection Agency, 1998).

There are about 2,000 different Salmonella organisms. These are classified by the protein antigenic types that make up their cell walls ("O" antigens) and flagella ("K" antigens). They can be further classified by phage typing.

Table 6: Main Species of Salmonellae Associated with Eggs

Species	**Phage Types**	**Impact**
typhimurium	42, 46	Most common serotype isolated from animals in New Zealand. (Midwinter 1999).
	44, 170, 179, 185	Reported from Australia. Some isolates resistant to antibiotics.
	12, 104, 170, 193, 195, 208	Reported from the UK. Many isolates resistant to antimicrobial agents
	DT 104	Causes disease in many species of animals including humans. Considered to be an emerging pathogen. Resistant to 5 commonly used antibiotics (ampicillin, chloramphenicol, streptomycin, sulfonamides and tetracycline). Rare in NZ.
enteritidis	4	Trans-ovarian so can be passed from infected layer hen to egg. Most common phage type associated with egg-borne outbreaks in UK and USA.
	6, 8, 9a, 13, 13a	Trans-ovarian
gallinarum		Trans-ovarian Affects animal health – Fowl typhoid
pullorum		Trans-ovarian Affects animal health – Pullorum disease

Table 7: Food-borne illness Associated with Salmonellae

Acute symptoms:	Nausea, vomiting, abdominal cramps, diarrhoea, fever, and headache.
Chronic consequences:	May get arthritic symptoms 3-4 weeks after onset of acute symptoms.
Onset time:	6-48 hours.
Infective dose:	As few as 15-20 cells; depends upon age and health of host, and strain differences among the members of the genus.
Duration of symptoms:	Acute symptoms may last for 1 to 2 days or may be prolonged, again depending on host factors, ingested dose, and strain characteristics.
Associated Foods:	Raw meats, poultry, eggs, milk and dairy products, fish, shrimp, frog legs, spices, yeast, coconut, sauces, salad dressing, cake mixes, cream-filled desserts and toppings, dried gelatin, peanut butter, cocoa, and chocolate. Various *Salmonella* species have been isolated from the outside of egg shells.

The egg is not an ideal environment for growth of salmonellae. It has been found that most salmonellae do not grow in eggs below 10°C (ICMSF, 1998). Despite the egg's defensive qualities, salmonellae are the most important human pathogen carried by eggs. *Salmonella* Typhimurium was previously the species most often implicated in egg-associated outbreaks but in many countries *Salmonella* Enteritidis is now the species of concern.

4.1.1 New Zealand Situation

Total results (not necessarily egg related):

In New Zealand the Environmental and Science Research Limited-Communicable Disease Centre (ESR-CDC) acts as the *Salmonella* reference laboratory. Isolates from many New Zealand laboratories, including MAF's Animal Health Laboratories, are sent there for typing (Carman and Gardner, 1997).

4.1.1.1 Salmonella Typhimurium

The phage types for which antibiotic resistance has been recorded overseas are uncommon or absent in specimens submitted to the Animal Health Laboratories. (Midwinter, 1999). The following phage types have been isolated in 1995 and 1996 from cattle, sheep, other livestock and miscellaneous sources including cats, dogs, birds and possums by the Animal Health Laboratories: 1, 8, 9, 12a, 23, 26, 41, 42, 60, 80, 101, 126, 135, 149, 154, 155, 156, 193, 197, 205. Phage type 104 was not isolated in these years and was less than 0.3% of non-human *Salmonella* Typhimurium isolates in 1994. (Midwinter 1999).

Salmonella Typhimurium phage type 160 has been isolated from sparrows in New Zealand (MOH, 2001). Chickens (broilers at least) are relatively resistant to the effects of *Salmonella* Typhimurium phage type 160, compared with other birds, such as young turkeys, pheasants and quail that suffer quite high mortality. Chickens are more likely to become sub-clinically infected (Christensen, personal communication, 2001). Apramycin has proved effective in halting mortality. Meganvac1 vaccination is registered for poultry in New Zealand. As a live vaccine that is applied to the birds by eye drop or coarse spray, it is a non-invasive and effective means of protecting at-risk populations. The source of the *Salmonella* Typhimurium phage type 160 was found to be contaminated shavings (Christensen, Unknown).

In New Zealand *Salmonella* Brandenburg has historically been isolated from small numbers of humans and a range of domestic animals. However in 1996, a unique strain of *Salmonella* Brandenburg was diagnosed as the cause of sheep abortions in mid-Canterbury. It causes ewes in late pregnancy to become very dull and fevered, they abort and occasionally they develop severe diarrhoea. If the ewes are not treated immediately with broad spectrum antibiotics they die. Since then, the disease has spread south. Cases of abortion in cattle were first diagnosed in 1998 and are now increasing. This strain has not been isolated from animals in the North Island. Why it has not progressed north of Canterbury to date is not clear at this stage. The flare-up of *Salmonella* Brandenburg in South Island sheep flocks during the past four years is mainly an animal health problem to this point, but there have been human cases (mainly people working with affected stock) (MAF, 1998; MAF, 2001).

If *Salmonella* Brandenburg should appear in meat and bone meal, this would have implications for feed, and therefore indirectly for egg production.

4.1.1.2 Salmonella Enteritidis

Salmonella Enteritidis is present in New Zealand and has been recovered from a range of domestic species, (cattle, sheep, goats, deer and dogs) as well as humans. It has also been isolated from a suburban hedgehog (*Erinaceus europeus*), from environmental sources, once from poultry feed, and from imported products such as prawns and spices (Carman and Gardner, 1997).

Salmonella Enteritidis appears to be increasing in New Zealand. Initially only sporadic isolates were recovered, e.g. one in 1985 (from cattle), one in 1988 (from cattle), and two in 1990 (one from a sheep and the other from sewage sludge). To put this into perspective, the ESR-CDC handled 610 poultry and 943 other domestic animal *Salmonella* isolates between 1988 and 1990. Only the two animal isolates referred to above were *Salmonella* Enteritidis (Carman and Gardner, 1997).

From about 1990 the situation began to change. Isolates of *Salmonella* Enteritidis began to appear more frequently in both humans and animals. By 1994 there had been 32 isolations of *Salmonella* Enteritidis from domestic animals, 27 of these were from cattle. The number of isolates in 1994 was double that of the previous year. Human isolates remained in the 10-20 range between 1985 and 1989, but by 1994 had risen to around 150. However, the percentage of all *Salmonella* isolates from humans that are *Salmonella* Enteritidis appears to be fairly constant in New Zealand at 6.5%. This situation contrasts with the United Kingdom and United States where 21-71% of human *Salmonella* isolates are *Salmonella* Enteritidis (Carman and Gardner, 1997).

Phage typing of New Zealand animal isolates began in 1986 and most have been phage type 9A. One bovine isolate in each of 1988, 1991 and 1992 was phage type 4. Phage type 4 has only been recovered from a few human patients who acquired their infections overseas. Occasional other phage types have been isolated, including phage type 26 from shellfish and effluent and assorted other phage types from humans (Carman and Gardner, 1997).

Key Messages to New Zealand Egg Producers:

Salmonella Enteritidis is present in New Zealand. This is a concern, given the problems that it has caused egg producers overseas.

4.1.1.3 Poultry and Eggs

A survey of New Zealand egg producers showed that 12 out of 15 respondents have tested for *Salmonella* as part of their routine quality assurance programmes, some for as long as 7 years. Samples included whole shell eggs, eggs without shell, feed, and swabs from the laying shed. All eggs tested have been negative for *Salmonella*. 4 respondents also tested for *Salmonella* Enteritidis and none has been detected. Most feed and swab samples were negative for *Salmonella* but there have been occasional positive results. This indicates that there could be a low likelihood that eggs will be contaminated with *Salmonella* from these sources. It must be remembered that the survey was not statistically based so responses are not necessarily typical of the New Zealand situation. The survey was done only to get some rapid indicative data. Any sampling that is done to support validation and ongoing testing programmes should be set up in a statistically sound manner. The following sampling plan will detect *Salmonella* Enteritidis-infected flocks with approximately 95% confidence that the flock contains no *Salmonella* Enteritidis birds:

Flock Size	**No. birds**	**Eggs after 5% production level achieved**
Less than 40 birds	Test all birds	First 40 eggs
40 to 120 birds	Test all birds	First 80 eggs
120 to 300 birds	Test 120 birds	First 100 eggs
300 to 500 birds	Test 150 birds	First 125 eggs
More than 500 birds	Test 175 birds	First 150 eggs

Figures ex Table 11, Healthy Free Range Hens, Christensen, 1995.

The emergence of *Salmonella* Enteritidis infection in New Zealand is evident records from the MAF Animal Health Laboratory and the Institute of Environmental Science and Research's Communicable Disease Centre (ESR-CDC) since 1985. To date, *Salmonella* Enteritidis has not been recovered from poultry products or eggs (Carman and Gardner, 1997). *Salmonella* Enteritidis has never been isolated from commercial poultry or from any other avian species in New Zealand (O'Neil, 1998).

Unlike overseas, New Zealand does not have any evidence that *Salmonella* Enteriditis phage type 4 is in the poultry food chain (MAF, 1997). New Zealand has a unique and superior animal health status in its poultry flocks. There are several exotic poultry diseases and food poisoning organisms that are present in overseas countries but not in New Zealand.

Key Messages to New Zealand Egg Producers:

This shows that even though we do have *Salmonella* Enteritidis in New Zealand, it has not yet been associated with eggs. **This is a status worth protecting.**

Salmonella Pullorum

Pullorum disease is only relevant for animal health. It has not been recorded in New Zealand since 1985 as shown by serological monitoring of commercial breeder flocks (MAF, 1997). *Salmonella* Pullorum, the causative agent of pullorum disease (also known as bacillary white diarrhoea), can be transmitted in eggs layed by adult birds without symptoms that carry the organism. They can also contaminate feed, water and the environment with their faeces. The oral infective dose for humans is high so the public health significance is low.

4.1.1.4 Salmonella Gallinarum

Salmonella Gallinarum causes fowl typhoid, but is exotic to New Zealand. If it did enter New Zealand, it would only be of relevance as a hazard to animal health. (MAF, 1997).

4.1.2 Overseas Situation

Salmonella Enteritidis

The incidence of *Salmonella* contamination of shell eggs from hens varies, but salmonellae have been detected at a level of 6 contaminated eggs per thousand eggs from flocks infected with *Salmonella* Enteritidis (Humphrey *et al*, 1991). Internal contamination of the intact eggs can occur before or after the shell has been formed.

Egg production in flocks infected with *Salmonella* Enteritidis may not be adversely affected. Subclinical infections also do not result in a decrease in fertility. Not all birds in an infected layer flock will excrete the pathogen, and the proportion of infected eggs that are laid varies. Most studies show the percentage to be below 3%. One study had the incidence as high as 19% (ICMSF, 1998).

Salmonella Enteritidis can cause mortality in young chicks, but rarely causes clinical disease in adult birds. It can infect internal organs, including the ovaries and oviduct (ACMSF, 1993).

Humphrey *et al* 1991, found that the contents of 32 (0.6%) of 5700 eggs were positive for *Salmonella* Enteritidis and not for any other serotype, even though *Salmonella* Enteritidis, *Salmonella* Hadar and *Salmonella* Typhimurium were also isolated from the shell. They also found that of 1952 eggs tested, 21 were positive for *Salmonella* Enteritidis on the shells and 18 in the contents. In most cases *Salmonella* Enteritidis was found more frequently in the albumen but at a much lower number than in the yolk. The albumen’s natural defences minimise the growth of these bacteria. The protein-rich yolk provides a better environment for their growth. In eggs stored for longer than 14 days, the yolk’s membrane starts to deteriorate and the yolk’s constituents move into the albumen. This provides food to support growth. *Salmonella* Enteritidis that is already inside the egg is likely to multiply faster than Salmonellae that have to migrate through the shell to the yolk.

In a number of countries, *Salmonella* Enteritidis phage type 4 is controlled by, the eradication of infected flocks, or the pasteurisation of eggs from infected flocks. This can also be accompanied by consumers education about correct cooking of eggs.

4.1.3 Australian Situation

Until recently, most human cases of *Salmonella* Enteritidis in Australia were believed to have been acquired overseas, where *Salmonella* Enteritidis is closely linked to the poultry industry. Over Easter 2000, four human cases of *Salmonella* Enteritidis phage type 4 occurred in Tasmania. Two of the human cases were linked but the other two cases had no obvious links. There were no further human cases reported and a check with other states did not reveal any cases with links to Tasmania.

No connection was established between the human *Salmonella* Enteritidis phage type 4 cases and any Tasmanian or Australian poultry farm or product. *Salmonella* Enteritidis, which has tentatively been identified phage type 1, was recovered from environmental drag swabs on a poultry farm in southern Tasmania. This farm was investigated after a traceback from the human cases. While *Salmonella* Enteritidis was not isolated from the poultry on the farm it was assumed that the birds were infected. As the *Salmonella* Enteritidis isolated from the suspect farm was a different phage type to the human cases this broke the link between the two events. It is unknown where the infection on the suspect farm came from, or if *Salmonella* Enteritidis was present in other layer flocks.

Export certification for poultry and poultry products relies to some extent on the ability to certify freedom from *Salmonella* Enteritidis, as do import restrictions on poultry products entering Australia. As *Salmonella* Enteritidis had not previously been detected in a poultry flock there was no agreed strategy for the control of the infection.

At this time, Tasmania was not involved in overseas export of poultry products and had only limited interstate trade. The DPIWE, DHHS and representatives of the Tasmanian layer industry proposed a response to address human health concerns from a Tasmanian perspective including:

- Development of a cold chain for the product, from production to consumption, to reduce the risk of multiplication of potentially pathogenic organisms. This required development of cold storage on farm, transportation in insulated vehicles, refrigeration at retail outlets, and on carton advice about refrigeration.
- On-farm Quality Assurance / HACCP program targeted at food safety on farms.
- Industry were advised to source birds only from accredited *Salmonella* Enteritidis-free flocks (at the time only New South Wales could provide this).
- A drag swab survey of the layer industry was to be conducted to determine the extent of the problem. If *Salmonella* Enteritidis was detected then birds were to be sampled.
- Carton date marking.
- Media releases were made containing general consumer advice about the need to refrigerate and properly cook eggs.
- High risk outlets (institutions) receiving eggs from the suspect farm were directly targeted by DHHS with appropriate advice.

Key Messages to New Zealand Egg Producers:

The key message here is that this is close to home. It could happen in New Zealand. Again prevention is better than cure.

4.1.4 UK Situation

Prior to the 1980s, *Salmonella* Typhimurium was the species of salmonellae that was implicated in most egg-associated food poisoning outbreaks. In the UK more than 80% of the *Salmonella* Typhimurium isolates from animal sources were phage type 104 (Midwinter 1999).

Salmonella Enteritidis came into prominence in Britain in the late 1980s due to outbreaks of human disease associated with eggs and poultry products. Shell eggs have been implicated as one of the food vehicles that may be responsible for transmission of the organism. By 1987 the associated publicity had resulted in enormous economic damage to the poultry industry (Carman and Gardner, 1997).

Since the 1980s, *Salmonella* Enteritidis was increasingly isolated from poultry and eggs. There was also a sharp increase in human salmonellosis associated with the consumption of foods containing raw or undercooked eggs (ICMSF, 1998).

One in 650 British eggs are positive for Salmonellae and 1 out of 880 for *Salmonella* Enteritidis. One out of 370 eggs imported into the UK were found to be contaminated with *Salmonella* and one out of 2,720 with *Salmonella* Enteritidis. (ACMSF, 1993).

Salmonella Enteriditis phage type 4 is now the most common salmonella serotype associated with food borne infections. A survey of eggs destined for retail sale showed a contamination rate of 0.04 – 0.11% for *Salmonella* Enteritidis. Only 0.03-0.08% were of Phage Type 4 (de Louvois, 1993). This low level was probably due to the fact that eggs from positive flocks were mixed with eggs from negative flocks so the overall incidence was very small.

The following recommendations were made by the Chief Medical Officer to reduce the risk of human Salmonellosis from eggs (ACMSF, 1993):

- No-one should eat raw eggs.
- Vulnerable groups should eat only eggs that have been cooked until both the white and yolk are solid.
- Eggs should be used within 3 weeks of lay and “use-by” dates should be provided on egg packs and possibly on eggs.
- Eggs should be kept at a constant temperature during storage, transport and retailing and should never exceed 20°C.
- Once purchased, eggs should be stored in a refrigerator.
- Pasteurised eggs should be substituted in raw or lightly cooked egg dishes.

In England and Wales in 1999 there was a 34% fall in the incidence of Salmonellosis from figures in 1998. The 1999 result was the best since 1986 (Editors, 2000). This was attributed as possibly being due to:

- Improvements in food hygiene, and
- Vaccinations of poultry flocks.

Key Messages to New Zealand Egg Producers:

The experience gained in the United Kingdom for control of *Salmonella* in eggs demonstrates that a risk management programme with appropriate controls[7] will also be beneficial to egg safety and industry security in New Zealand.

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[7] In New Zealand there are no *Salmonella* vaccines registered for use in layer hens. Currently Meganvac 1 (ARB 7935) is registered for use in broilers, and has been used in breeders and layer hens. It has also been successfully used to protect a variety of poultry species (turkeys, quail, ducks, pheasants) against clinical infection with *Salmonella* Typhimurium PT160. The vaccines used in Europe are killed oil emulsion vaccines, whereas Meganvac is an attenuated live vaccine. Killed vaccines produce largely humoral (circulating) antibodies, whereas live vaccines produce a full range of immune responses including the important cell mediated responses, which are vital in protecting hens against intestinal colonisation. Humoral antibodies play some role in protection where the bacteria are in the blood (i.e. *Salmonella* Enteritidis) but not in the enteric infections currently important in New Zealand.

4.1.5 European Situation

The Seventh Report of the World Health Organisation Surveillance Programme for Foodborne Diseases in Europe, 1993-98, reported that salmonellae caused most foodborne infections in the majority of European countries. *Samonella* Enteritidis was the most commonly reported serotype. (WHO, 2001).

Key Messages to New Zealand Egg Producers:

The food-borne illness data in section 3.3.3 shows that there is a huge difference in the number of illnesses linked to eggs in different countries. The reasons for this have not been stated but may be due to the prevalence of *Salmonella* Enteritidis in the national poultry flocks.

4.1.6 USA Situation

The Centers for Disease Control (CDC) has recorded more than 120 outbreaks of *Salmonella* Enteritidis to date, many occurring in restaurants, and some in nursing homes, hospitals and prisons. In August and September, 1985, *Salmonella* Enteritidis was isolated from employees and patrons of restaurants of a chain in Maryland. The outbreak in one restaurant included at least 71 illnesses, resulting in 17 hospitalisations. Scrambled eggs from a breakfast bar were implicated in this outbreak.

The CDC estimates that 75% of *Salmonella* Enteritidis outbreaks are associated with the consumption of raw or inadequately cooked Grade A whole shell eggs. The U.S. Department of Agriculture published Regulations on February 16, 1990, in the Federal Register establishing a mandatory testing program for egg-producing breeder flocks and commercial flocks implicated in causing human illnesses. This testing was expected to lead to a reduction in cases of gastroenteritis caused by the consumption of Grade A whole shell eggs.

During 1976-1994, the proportion of reported Salmonella isolates that were *Salmonella* Enteritidis increased from 5% to 26%. CDC surveillance data show that the rate if isolation of *Salmonella* Enteritidis has increased from 0.5 to 3.9 per 100,000 population during the period from 1976 to 1994. In the 1980s, the main phage types in the United States were 8 and 13. Subsequently phage type 4 was detected (Carman and Gardner, 1997). During 1985-1995, state and territorial health departments reported 582 *Salmonella* Enteritidis outbreaks, which accounted for 24,058 cases of illness, 2290 hospitalizations, and 70 deaths. Grade A whole shell eggs or foods that contained raw or undercooked eggs were found to be a major source of *Salmonella* Enteritidis human infections in the United States (ACMSF, 1993).

Several outbreaks of *Salmonella* Enteritidis infection associated with the consumption of raw shell eggs in the United States from 1994 to 1995 were reported in the CDC's National *Salmonella* Surveillance System (CDC, 1996). Four outbreaks were linked to hollandaise sauce prepared with raw eggs, eggs prepared for breakfast at a nursing home (where 3 people died as a result), Caesar salad dressing made with raw eggs and a Jamaican malt drink prepared with raw eggs. These examples indicate that outbreaks of egg-associated *Salmonella*

Enteritidis infections remain a public health problem in the United States. The case-fatality rate in institutions was 70 times higher than in outbreaks in other settings. This underscores the importance of using pasteurised egg products for all recipes requiring pooled, raw, or undercooked shell eggs for the institutionalised elderly and other high-risk populations.

It is estimated that 2 to 4 million cases of Salmonellosis occur in the United States annually. The incidence of *Salmonella* Enteritidis increased 6 fold from 1976 to 1990 in the north-eastern United States (Rodriguez *et al*, 1990). The increase in human infections is spreading south and west, with sporadic outbreaks in other regions (USFDA CFSAN, 2000). The Northeast of the USA has shown a decrease in isolations from 1990-1994 over the period that increased egg quality assurance efforts have been implemented. (USDA, 1999c).

2.3 million of 46.8 billion shell eggs produced annually in the United States are infected with *Salmonella*. The USDA and the FDA are considering requiring sell by dates on fresh eggs, controlling truck temperatures and tracking *Salmonella* among flocks nationwide (Reuters, 1999). Approximately one in every 20,000 eggs is infected with *Salmonella* Enteritidis, a significant source of food poisoning since the 1980s. A peak of 3.6 cases for every 100,000 people was reached in 1996. By 1998 the rate had dropped to 2.2 cases per 100,000 (Brasher, 2000).

Key Messages to New Zealand Egg Producers:

The overseas data clearly shows that *Salmonella* Enteritidis is a major hazard to egg safety in many countries. Visitors from overseas and New Zealanders travelling overseas may bring *Salmonella* Enteritidis infections back into New Zealand. The fact that this bacterium has already been detected in New Zealand, though not from eggs, suggests that there is a potential risk of this bacterium becoming established in New Zealand. It is recommended that New Zealand egg producers consider implementing relevant controls (perhaps some of those used by other countries, particularly the UK and USA) to minimise the risk of *Salmonella* Enteritidis becoming established in the New Zealand egg production sector.

4.2 Campylobacter jejuni

Where a reference has not been specifically given the information on this page has been adapted from the "Bad Bug Book" (USFDA CFSAN, 2000).

Campylobacter jejuni is recognised as a major source of foodborne illnesses, usually associated with the consumption of contaminated raw milk, undercooked meat or undercooked poultry products.

Campylobacter jejuni is a relatively fragile bacterium which is sensitive to environmental stresses (e.g., 21% oxygen, drying, heating, disinfectants, acidic conditions). *Campylobacter jejuni* is often isolated from healthy cattle, chickens, birds and even flies. It is sometimes present in non-chlorinated water sources such as streams and ponds.

Table 8: Food-borne illness Associated with *Campylobacter jejuni*

Symptoms:	*Campylobacter jejuni* infection causes diarrhoea, which may be watery or sticky and can contain blood and white cells. Other symptoms often present are fever, abdominal pain, nausea, head ache and muscle pain.
Onset time:	Illness usually 2-5 days after ingestion of contaminated food or water.
Infective dose:	This is considered to be small. Human feeding studies suggest that about 400-500 bacteria may cause illness in some individuals, while in others, greater numbers are required.
Duration of symptoms:	Illness generally lasts 7-10 days, but relapses are not uncommon (about 25% of cases). Most infections are self-limiting and are not treated with antibiotics. However, treatment with erythromycin reduces the length of time that infected individuals shed the bacteria in their faeces.
Complications:	These are relatively rare, but include reactive arthritis, haemolytic uremic syndrome, and following septicemia, infections of nearly any organ. The fatality rate for *Campylobacter jejuni* infections is 0.1, i.e. one death per 1,000 cases (usually occurs in debilitated patients). Only 20 reported cases of septic abortion induced by *Campylobacter jejuni* have been recorded in the literature. Meningitis, recurrent colitis, acute cholecystitis and Guillain-Barre syndrome are very rare complications.
Associated Foods:	*Campylobacter jejuni* frequently contaminates raw chicken (not surprising as many healthy chickens carry these bacteria in their intestinal tracts). Raw milk and non-chlorinated water may also be a source of infections.

4.2.1 NZ Situation

In New Zealand, *Campylobacter* infections accounted for 67% of reported gastrointestinal illnesses from all sources. (NZCDC, 1989). In the 12 months up to and including May 2001 there have been 524 cases of campylobacteriosis at a rate of 222.4 cases per 100,000 people (ESR, 2001). The presence of the organism in or on eggs in New Zealand is currently unknown.

4.2.2 Overseas Situation

Campylobacter jejuni is the leading cause of bacterial diarrhoea in the U.S.A. Potential sources of *Campylobacter* are flies, wild birds, rodents, water or contaminated equipment. (FSIS, 1999). Laying flocks are frequently infected with *Campylobacter jejuni* but when infected birds lay eggs the surface of the egg shells are rarely positive. When the organism is present it dies off rapidly under normal egg storage conditions. It is therefore unlikely that *Campylobacter* is transmitted via eggs (ICMSF, 1998).

Key Messages to New Zealand Egg Producers:

The ICMSF data suggests that Campylobacter is unlikely to be a hazard to egg safety. There is no evidence to suggest that it would be any different in New Zealand.

4.3 Listeria monocytogenes

Where a reference has not been specifically given the information on this page has been adapted from the "Bad Bug Book" (USFDA CFSAN, 2000). Listeria is a bacterium. Some studies suggest that 1-10% of humans may be intestinal carriers of *Listeria monocytogenes*. It has been found in at least 37 mammalian species, both domestic and feral; at least 17 species of birds; some species of fish and shellfish; soil, silage, and other environmental sources. It is quite hardy and resists the deleterious effects of freezing, drying, and heat remarkably well for a bacterium that does not form spores. Most *Listeria* are pathogenic to some degree.

Table 9: Food-borne illness Associated with *Listeria monocytogenes*

Symptoms of Listeriosis:	Septicemia, meningitis, encephalitis, and intrauterine or cervical infections in pregnant women, which may result in spontaneous abortion (2nd/3rd trimester) or stillbirth.
Onset time:	The above disorders are usually preceded by influenza-like symptoms including persistent fever. It was reported that gastrointestinal symptoms such as nausea, vomiting, and diarrhoea may precede more serious forms of listeriosis or may be the only symptoms expressed. The onset time to serious forms of listeriosis is unknown but may range from a few days to three weeks. The onset time to gastrointestinal symptoms is unknown but is probably greater than 12 hours.
Infective dose:	Unknown but believed to vary with the strain and susceptibility of the victim. Fewer than 1,000 total organisms may cause disease.
Complications/ Mortality:	The 1987 incidence data collected by CDC suggests that there are at least 1600 cases of listeriosis with 415 deaths per year in the U.S. The vast majority of cases are sporadic, making epidemiological links to food very difficult. Most healthy persons probably show no symptoms. When listeric meningitis occurs, the overall mortality may be as high as 70%; from septicemia 50%, from perinatal/neonatal infections greater than 80%. In infections during pregnancy, the mother usually survives.
Susceptible persons:	• pregnant women/fetus - perinatal and neonatal infections; • persons with defective immune systems due to corticosteroids, anticancer drugs, graft suppression therapy, AIDS; • cancer patients - leukemic patients particularly; • less frequently reported - diabetic, cirrhotic, asthmatic, and ulcerative colitis patients; • the elderly; • normal people--some reports suggest that normal, healthy people are at risk, although antacids or cimetidine may predispose.
Associated Foods:	*Listeria monocytogenes* has been associated with such foods as raw milk, supposedly pasteurised fluid milk, cheeses (particularly soft-ripened varieties), ice cream, raw vegetables, fermented raw-meat sausages, raw and cooked poultry, raw meats (all types), and raw and smoked fish. Its ability to grow at temperatures as low as 3°C permits multiplication in refrigerated foods.

4.3.1 NZ Situation

The presence of the organism in or on eggs produced in New Zealand is currently unknown.

4.3.2 Overseas Situation

Listeria monocytogenes can be isolated from poultry flocks and the birds' immediate environment. It is likely that Listeria is present on the shells of freshly laid eggs. (ICMSF, 1998). Listeriosis has been observed in chickens and at least 22 other avian species such as turkeys, ducks, geese and pheasants. Sporadic cases are often accompanied by shedding of *Listeria monocytogenes* in faeces but without any symptoms (Ryser and Marth, 1991).

No cases of foodborne illnesses due to Listeriosis traceable to eggs were firmly documented over a 40-year period. There was however one outbreak tentatively linked with eggs. (Ryser and Marth, 1991). Listeria is able to survive on eggs stored at 5°C for 90 days. This indicates that eggs may be a potential vehicle for Listeria related food poisoning – especially from cracked eggs. Some studies have shown that the virulence of *Listeria monocytognes* increases when it is grown at low temperatures (Ryser and Marth, 1991).

Urbach and Schabinski (1955) found that numbers of *Listeria monocytognes* in whole shell eggs increased nearly six-fold during 10 days of storage at ambient temperature. Another study found that growth of *Listeria monocytogenes* was mainly in the egg yolk with generation times of 1.7 days at 5°C and 2.4 hours at 20°C (Ryser and Marth, 1991). Interestingly the overall numbers of Listeria over a period of storage remained the same but the number decreased dramatically in raw albumen (partially due to high pH) while the numbers in the yolk increased.

Key Messages to New Zealand Egg Producers:

The overseas data suggests that *Listeria* is likely to be present on freshly laid eggs, and is likely to be able to survive during storage. The impact on human health is unclear.

4.4 Miscellaneous enterics (intestinal bacteria)

Where a reference has not been specifically given the information in this section has been adapted from the "Bad Bug Book" (USFDA CFSAN, 2000).

A number of different bacteria may contaminate the external surface of the egg, during or shortly after lay. These include: *Klebsiella, Enterobacter, Proteus, Citrobacter, Aerobacter, Providencia,* and *Serratia.* These enteric (intestinal) bacteria have been suspected of causing acute and chronic gastrointestinal disease. The organisms may be recovered from natural environments such as forests and freshwater as well as from farm produce (vegetables) where they reside as normal microflora. They may be recovered from the stools of healthy individuals with no disease symptoms. The relative proportion of pathogenic to nonpathogenic strains is unknown.

Table 10: Food-borne illness Associated with Enteric Bacteria

Acute Symptoms:	Gastroenteritis: Two or more of vomiting, nausea, fever, chills, abdominal pain, and watery diarrhoea occurring 12-24 hours after ingestion of contaminated food or water.
Chronic Symptoms:	Dysenteric symptoms: foul-smelling, mucus-containing, diarrheic stool with flatulence and abdominal distention. The chronic disease may continue for months and require antibiotic treatment.
Infective dose:	Unknown
Complications/ Mortality:	Healthy individuals recover quickly and without treatment from the acute form of gastrointestinal disease. Malnourished children (1-4 years) and infants who endure chronic diarrhoea soon develop structural and functional abnormalities of their intestinal tracts resulting in loss of ability to absorb nutrients. Death is not uncommon in these children and results indirectly from the chronic toxigenic effects which produce poor absorption and malnutrition.
Associated Foods:	Dairy products, raw shellfish, and fresh raw vegetables. The organisms occur in soils used for crop production and shellfish harvesting waters and, therefore, may pose a health hazard.

4.4.1 NZ Situation

A survey of New Zealand egg producers showed that only one had been testing whole shell eggs for E. coli. All 100 tests to date have been negative.

4.4.2 Overseas Situation

The incidence of eggs contaminated with Enterobacteriaceae increases with flock age (Bruce and Johnson, 1978) possibly due to an increase in the number of eggs with poor cuticles as the flocks age (Bruce and Drysdale, 1994). The initial flora of liquid eggs is similar to that found on egg shells. Under good manufacturing practices total counts in raw liquid eggs below 10^6cfu ml^{-1} and *E. coli* below 10^2 are easily achievable (Mossel *et al*., 1995).

A Korean study tested 135 dozen shell eggs for the presence of *Salmonella* spp. None of the egg yolks were found to contain *Salmonella* organisms but *Escherichia coli*, *Escherichia hermanii*, and *Citrobacter freundii* were isolated from egg shells. (Chang, 2000). In 1997, Papadopoutou *et al* reported that they had isolated the following bacteria from hen's eggs: *Staphylococcus aureus*, *Enterococcus faecalis*, *Escherichia coli*, *Enterobacter cloacae*, Proteus species, *Pseudomonas stutzeri* and *Citrobacter freundii*.

Key Messages to New Zealand Egg Producers:

The overseas data suggests that enteric microorganisms and other bacteria are likely to be present on freshly laid eggs but the impact on human health is unclear.

4.5 Staphylococcus aureus

Staphylococcus aureus is a bacterium. Some strains are capable of producing a highly heat-stable enterotoxin that causes illness in humans.

Staphylococci exist in air, dust, sewage, water, milk, and food or on food equipment, environmental surfaces, humans, and animals. Humans and animals are the primary reservoirs. Staphylococci are present in the nasal passages and throats and on the hair and skin of 50 percent or more of healthy individuals. This incidence is even higher for those who associate with or who come in contact with sick individuals and hospital environments. Although food handlers are usually the main source of food contamination in food poisoning outbreaks, equipment and environmental surfaces can also be sources of contamination with *Staphylococcus aureus*. Human intoxication is caused by ingesting enterotoxins produced in food by some strains of *Staphylococcus aureus*, usually because the food has not been kept hot enough (60°C, 140°F, or above) or cold enough (7.2°C, 45°F, or below).

Table 11: Food-borne illness Associated with *Staphylococcus aureus*

Symptoms:	Nausea, vomiting, retching, abdominal cramping, and prostration. Some individuals may not always demonstrate all the symptoms associated with the illness. In more severe cases, headache, muscle cramping, and transient changes in blood pressure and pulse rate may occur. Recovery generally takes two days, but complete recovery may take three days and sometimes longer in severe cases.
Onset:	Usually rapid and in many cases acute, depending on individual susceptibility to the toxin, the amount of contaminated food eaten, the amount of toxin in the food ingested, and the general health of the victim.
Infective dose:	A toxin dose of less than 1.0 µg in contaminated food will produce symptoms of staphylococcal intoxication. This toxin level is reached when *Staphylococcus aureus* populations exceed 100,000 per gram.
Complications/ Mortality:	Death from staphylococcal food poisoning is very rare, although such cases have occurred among the elderly, infants, and severely debilitated persons.
Associated Foods:	Foods that are frequently incriminated in staphylococcal food poisoning include meat and meat products; poultry and **egg products**; salads such as **egg**, tuna, chicken, potato, and macaroni; bakery products such as cream-filled pastries, cream pies, and chocolate eclairs; sandwich fillings; and milk and dairy products. Foods that require considerable handling during preparation and that are kept at slightly elevated temperatures after preparation are frequently involved in staphylococcal food poisoning.

Key Messages to New Zealand Egg Producers:

The data suggests that *Staphylococcus aureus* has been linked with food-borne illness associated with eggs and egg products. One of the main reservoirs of this bacteria is humans so the control of personal hygiene is very important when working with eggs.

4.6 Streptococcus species.

Streptococci are bacteria. They have been split into a number of groups based on characteristics that can be checked in the laboratory (Groups A, B, C, D, F, and G). Groups A and D can be transmitted to humans via food.
Group A: one species with 40 antigenic types (*S. pyogenes*).
Group D: five species (*S. faecalis*, *S. faecium*, *S. durans*, *S. avium*, and *S. bovis*).

Table 12: Food-borne illness Associated with *Streptococci*

	Group A	Group D
Illness:	Septic sore throat, scarlet fever, and other pyogenic / septicemic infections	May produce a clinical syndrome similar to staphylococcal intoxication.
Symptoms:	Sore and red throat, pain on swallowing, tonsilitis, high fever, headache, nausea, vomiting, malaise, rhinorrhea; occasionally a rash occurs, onset 1-3 days; the infectious dose is probably quite low (less than 1,000 organisms).	Diarrhoea, abdominal cramps, nausea, vomiting, fever, chills, dizziness in 2-36 hours following ingestion of suspect food. The infectious dose is probably quite high.
Complications/ Mortality:	Streptococcal sore throat is very common, especially in children. Usually it is successfully treated with antibiotics. Complications are rare and the fatality rate is low.	Diarrhoeal illness is poorly characterised, but is acute and self-limiting.
Associated Foods:	Food sources include milk, ice cream, **eggs**, steamed lobster, ground ham, potato salad, egg salad, custard, rice pudding, and shrimp salad. In almost all cases, the foodstuffs stood at room temperature for several hours between preparation and consumption.	Food sources include sausage, evaporated milk, cheese, meat croquettes, meat pie, pudding, raw milk, and pasteurised milk.
Entrance into Food:	Due to poor hygiene, ill food handlers, or use of unpasteurised milk. Most outbreaks have involved complex foods (i.e., salads) which were infected by a food handler with septic sore throat. One ill food handler may subsequently infect hundreds of individuals.	Due to under-processing and/or poor and unsanitary food preparation. Outbreaks are not common and are usually the result of preparing, storing, or handling food in an unsanitary manner.

Streptococcus species form part of the normal intestinal flora of poultry and are commonly found in poultry environments (MAF, 1997).

Key Messages to New Zealand Egg Producers:

The data suggests that *Streptococcus* has been linked with food-borne illness associated with eggs and egg products usually by contamination from infected food handlers. Thus the control of personal hygiene is very important when working with eggs.

4.7 Mycotoxins from fungi

Mycotoxins are toxic substances produced by fungi - often by *Aspergillus* and *Fusarium* species. Aflatoxicosis is described in the USDA's "Bad Bug Book" as "poisoning that results from ingestion of aflatoxins in contaminated food or feed." Aflatoxins are produced by certain strains of *Aspergillus flavus* and *Aspergillus parasiticus* under favorable temperatures and humidity.

Aflatoxins produce acute necrosis, cirrhosis, and carcinoma of the liver in a number of animal species. For most species, the LD50 value ranges from 0.5 to 10 mg/kg body weight. The toxicity can be influenced by environmental factors, exposure level, and duration of exposure, age, health, and nutritional status of diet. Aflatoxin B1 is a very potent carcinogen in many species, including non-human primates, birds, fish, and rodents. In each species, the liver is the primary target organ of acute injury. Aflatoxin M is a major metabolic product of aflatoxin B1 in animals and is usually excreted in the milk and urine of dairy cattle and other mammalian species that have consumed aflatoxin-contaminated food or feed (USDA CFSAN, 2000).

The adverse effects of aflatoxins in animals (and presumably in humans) have been categorised in two general forms.

- Acute aflatoxicosis:
  - when moderate to high levels of aflatoxins are consumed.
  - hemorrhage, acute liver damage, edema, alteration in digestion, absorption and/or metabolism of nutrients, and possibly death.
- Chronic aflatoxicosis:
  - when low to moderate levels of aflatoxins are ingested.
  - usually subclinical and difficult to recognise. Some of the common symptoms are impaired food conversion and slower rates of growth.

Although humans and animals are susceptible to the effects of acute aflatoxicosis, the chances of human exposure to acute levels of aflatoxin is remote in well-developed countries. (USDA CFSAN, 2000)

4.7.1 NZ Situation

Studies by Lauren *et al* have shown that there are mycotoxins in grain grown in New Zealand, particularly as a result of contamination with *Fusarium* species. The highest levels of contamination found were 16.6 mg/kg of zearalenone, and 7.4 mg/kg of Nivalenol in the leaf fraction of maize. 40-95 mg/kg of zearalenone, Nivalenol or deoxynivalenol were detected in the ear fractions of the maize. The levels in maize were not extrapolated to predict the subsequent levels that may be present in animal feed made with these grains. FDA permits 10 ppm (=mg/kg) in grains and by-product fed to chickens (Tarr, B, 1996).
Companies that import grain into New Zealand usually have maximum mycotoxin levels included in their purchasing specifications.

The presence of mycotoxins in eggs produced in New Zealand is currently unknown.

4.7.2 Overseas Situation

Deoxynivalenol is a toxin produced by *Fusarium graminearum*. Christensen *et al*, 1988 found that deoxynivalenol was not detected in the flesh or eggs from chickens that consumed a ration with 9.18 ppm of deoxynivalenol.

T-2 and diacetoxyscirpenol (DAS) are toxins that can be produced by a number of Fusarium species. Christensen, 1988, found that these toxins can result in reduced egg production in laying hens.

A number of studies have shown that poultry feed can be contaminated with mycotoxins. Oyejide *et al* found Aflatoxin B1 at between 0.57 and 2.55 micrograms/g in 68.6% of layer samples analysed in Nigeria (Oyejide *et al*, 1987). Moreno and Suarez (1995) isolated 49 strains of Aspergillus that produce aflatoxins from poultry mixed feeds. In 1996 Castella *et al* isolated fusarium species from 59.1% of mixed poultry feeds and of these isolates 97.4% were capable of producing fumonisin B1 or B2 – a mycotoxin.

Aflatoxins produced by *Aspergillus flavus* and *A. parasiticus* have been found in feeds that have a suitable environment for the growth of fungi, especially corn. Meronuck (1988) contends that “indirect exposure of humans to aflatoxins can occur by consumption of foods derived from animals that consume contaminated feeds” and gives milk from dairy cattle consuming contaminated feed as an example. No mention was made of this possibility in association with eggs.

An experiment was carried out where layers were fed aflatoxin B1-contaminated feed for 7 days, and then aflatoxin free feed for a further 7 days. The level of Aflatoxicol (R0) and B1 in eggs started at 0.02 to 0.2ng/g, then increased steadily for 4 or 5 days, plateaued, then decreased after contaminated feed was withdrawn. 7 days after withdrawal only trace amounts of R0 (0,01 ng/g) remained in the eggs (Trucksess *et al*, 1983).

Control of mycotoxins is best achieved by controlling fungal growth (e.g. using low moisture and temperatures, or by adding chemical preservatives such as propionic acid to grain or feed).

Key Messages to New Zealand Egg Producers:

The overseas data suggests that mycotoxins may sometimes be present in layer and other feed, but that the likely levels of contamination are well below the LD50 values that have been found to be toxic to most animal species.

5. Chemical Hazards

Chemical hazards that could be present in eggs include agricultural chemicals (pesticides, herbicides, veterinary drugs) and environmental contaminants (heavy metals, organochlorines).

5.1 Agricultural chemicals

Animal remedies are occasionally used to prevent disease and ensure the health of laying hens. Very few animal remedies are permitted and there is an economic incentive not to use them due to the additional cost.

5.1.1 NZ Situation

Animal remedies are approved for administration to layers in New Zealand by MAF's Agricultural Compounds and Veterinary Medicines Group. Antibiotics are not used as growth promotants in the egg production industry but there is some prophylactic use. A database of currently licensed animal remedies is available on the MAF web site at: http://www.maf.govt.nz/cgi-bin/db_search.cgi?setup_file=animal-rem-prod.setup.cgi. Further information on products is available by emailing requests to acvm@maf.govt.nz.

Some pesticides are used to control lice, mites etc in nest boxes. A database of currently registered pesticides is available on the MAF web site at: http://www.maf.govt.nz/cgi-bin/db_search.cgi?setup_file=pesticides.setup.cgi. Further information on products is available by emailing requests to acvm@maf.govt.nz.

An industry Veterinary source said that there are registered animal remedies available to control parasites and worms in the poultry industry. These organisms may be an issue for barn and free range birds. These animal remedies may be appropriate for use with layers and should not cause a residue problem if egg producers follow the manufacturers' instructions.

5.1.2 UK Situation

In the UK antibiotics are not a part of the laying hen's diet and are never used by the egg industry as growth promoters or routine treatments. Any use of antibiotics for laying hens must be prescribed by a veterinary surgeon and the eggs produced by these layers cannot be sold for the withdrawal period specified.

5.1.3 European Situation

In Europe the Veterinary Medicines Directorate's Annual Report on Surveillance for Veterinary Residues in 1998 showed that of 512 samples, each made up of a dozen eggs, 499 were free of detectable residues. Of the others 4 contained dimetridazole or its metabolite, 2 contained lasalocid and 7 contained nicarbazin residues, (VMD, 1998). Tracebacks found that contamination at the feed mill was the most likely source of most of these residues.

Key Messages to New Zealand Egg Producers:

The overseas data suggests that residues may be an issue in eggs. New Zealand's situation should be acceptable if egg producers are using registered products in accordance with registration details. Egg producers are considering setting up an industry residue monitoring programme to establish actual residue levels in this country.

5.2 Environmental contaminants

DDT (dichlorodiphenyltrichloroethane) was widely used in New Zealand in the 1950s and 60s. It was banned in 1970 but it has a half life of approximately 50 years and DDE (a breakdown product from DDT) has been detected in the food chain. The 1997/98 New Zealand Total Diet Survey (Cressey *et al*, 2000) showed that residues of DDT derivatives were detected in most foods of animal origin. The total DDT estimated dietary exposure has decreased from the survey done in 1990/91. This result was expected as the parent compound, pp-DDT, has been banned for some time. The survey concluded that the levels found were unlikely to have any adverse health implications for the New Zealand population. There was however one unexpected result. The parent compound, pp-DDT, was detected in one food sample (eggs). The report recommended that further work be undertaken to identify whether the presence of pp-DDT in eggs is a common occurrence, as its presence was unexpected, and indicates use of, or exposure to a deregulated pesticide.

An environmental survey of New Zealand soils showed that organochlorine pesticide residues (including DDT) were lower than for comparable environments reported overseas. DDT and DDE were found at all forest and grassland sites, but no residues exceeded 3µg/kg dry weight. Results of soil testing from provincial centres showed most were below 15µg/kg although the level in Invercargill was 121µg/kg. In metropolitan areas Auckland's result was similar to provincial areas, but Christchurch's concentrations were higher (in the range of 78.8 - 340µg/kg). Nevertheless, all of these results compared favourably to overseas data (Buckland *et al*, 1998).

Key Messages to New Zealand Egg Producers:

The pesticide levels found in the New Zealand total diet Survey are unlikely to have any adverse health implications for the New Zealand population. Organochlorine pesticide concentrations in forest and grassland soils, and in urban centres were lower than for comparable data overseas. The data does however suggest that residues of DDT derivatives are likely to be present at low levels in the environment, and that levels can vary significantly from one region to another. It would be advisable to test free range hen sites to check that residues are not above expected levels. Egg producers must also ensure that DDT is not used on their property.

5.3 Colourants in feed

5.3.1 NZ Situation

The colour of egg yolks and chicken skin depends entirely on what the birds eat, because animals cannot synthesise the pigments causing these colours. Therefore, to satisfy the consumer's perception that a rich, golden yolk means a healthier or tastier egg, (not actually true), feed manufacturers use pigments added to the feed. These pigments are four types:

1. "Natural" Red. This is usually made from Paprika, but the extraction methods involve chemical treatments. Some customers specify this red because it is from a natural plant source. *Salmonella* is often associated with paprika but it is likely that the process used to extract the colourant will kill any bacteria.
2. "Natural" yellow. This is from Marigold.
3. Synthetic Red. Artificially synthesised.
4. Synthetic yellow. Artificially synthesised.

Red and yellow are almost always used in combination. A typical inclusion might be 300-500 grams of natural pigments per tonne of feed (total red and yellow), or in the synthetic variety 50-100 grams per tonne of feed (Meads, 2000). The synthetic pigments are less variable and stronger so smaller quantities are required. The major suppliers in NZ are BASF and Roche, who have their own products. Other traders import products from China and Mexico. Anecdotal evidence from these suppliers suggests that they are not aware of any hazards associated with the use of these colorants in layer feed.

Canthaxanthin, an artificial colourant, is listed in the list of Oral Nutritional Compounds that are ‘Generally Recognised as Safe’ (GRAS) in the ACVM Regulations as stated in a letter issued by MAF on 14th December 2000 to RJ Diprose (MAF, 2000).

5.3.2 UK Situation

A newspaper article stated that a British supermarket chain has stipulated that canthaxanthrin is not to be used in layer feed as this substance may damage the eye’s retina. The article stated that Canthaxanthin (E161g) could be present in up to 65% of British eggs and that two other colourants, E161I and E160, have no known side-effects (Murphy, 1999). The article did not make reference to any scientifically credible literature to back up the claims.

Canthaxanthin has been approved for use as a colour additive in food in the European Economic Community (EEC number: E161g).

5.3.3 USA Situation

Canthaxanthin has been approved under the USA’s Code of Federal Regulations Section 73.75 where it is “approved for foods generally, not to exceed 30 mg/lb of solid or semisolid food or per pint of liquid food; May also be used in broiler chicken feed”. (USFDA, CFSAN, 2000a).

5.4 Dioxin

Dioxin is a general term for a group of chemicals, that contain chlorine and have similar chemical and physical properties. Dioxin is a man-made contaminant found in the environment at very low levels. Dioxin is produced during combustion processes, such as incineration of household, hospital, industrial waste and of sewerage sludge, and as an unwanted by-product of some industrial chemical processes. Dioxin is found in foods as a background contaminant at extremely low levels that are not considered to be of public health concern.

Dioxin is toxic to animals at high levels of exposure. It has been reported to affect the immune system, hormones and reproduction. Humans appear to be much less susceptible to the short-term effects of dioxin than animals. Industrial accidents have shown that the only significant effect was damage to the skin (chloracne).

Exposure to dioxin at relatively high doses from industrial accidents has been associated with long term toxic effects, including skin damage. There is only weak evidence of increased incidence of nonspecific cancers (International Programme on Chemical Safety IPCS monograph, WHO/IPCS Consultation 1998). The World Health Organization (WHO) established a safe level of intake for dioxin of 10 picograms/kilogram bodyweight in 1990 relating to life time exposure in humans. This was lowered to 1-4 picograms/kilogram bodyweight in 1998. It was not considered necessary to set a short term exposure level.

5.4.1 NZ Situation

Research by the Ministry for the Environment shows that levels of dioxins in New Zealand’s environment, in food and in people are low compared with other countries. (MFE, 2001).

5.4.2 USA Situation

In the USA the FSIS issued an advisory notice to egg producers and poultry custodians about possible exposure to high levels of dioxin in animal feed that may have rendered resulting food products adulterated. This was done after 2 out of 80 poultry samples were found by the FSIS and the Environmental Protection Agency to have unusually high levels of dioxin. The source of the contamination was ball clay which was added to soybean meal as a flowing or anti-caking agent. It was determined that the levels of dioxin in feed and foods produced from animals that consumed the feed presented no immediate health risk. The feed was however recalled to prevent any further exposure to elevated dioxin levels. FDA advised shell egg producers that products that contain dioxin at or above 1 part per trillion are deemed adulterated (FSIS, 1997).

5.4.3 European Situation

Fats contaminated with dioxin from recycled PCB oil were distributed to 11 feed mills (in Belgium, France and the Netherlands). These mills produced animal feed pellets that were distributed to over 1500 poultry, pork and cattle (beef and dairy) farms in Belgium, the Netherlands and France. Animals on these farms were fed the contaminated feed, and food produced from the animals has subsequently been traded with other European Union Member

States and to countries such as Australia. The level of dioxin in these foods (poultry, egg, pork, beef and dairy products) is unclear due to limited test results (ANZFA, 1999).

In response to public health concerns about the above contamination, the European Commission (EC) implemented a ban on 3 June 1999 on the marketing of foods from Belgium containing egg or poultry products, produced between 15 January and 1 June 1999 and later extended it to other products (ANZFA, 1999). Consumers were advised that the consumption of the contaminated foods under discussion would not be expected to cause harmful effects, due to the relatively short period of exposure (ANZFA, 1999).

Key Messages to New Zealand Egg Producers:

The problems that have been found overseas indicate that there is potential for dioxins to be inadvertently introduced into animal feed, including that for layer hens. This situation could occur in New Zealand. Egg producers should therefore obtain their feed from suppliers with appropriate quality and product safety systems.

6. Physical Hazards

Because of the protective nature of the shell, no physical hazards have been identified for whole shell eggs.

7. Risks to Wholesomeness

Wholesomeness, in relation to any regulated animal product, is defined in the Animal products Act 1999 to mean that: "**the product does not contain or have attached to it, enclosed with it, or in contact with it** anything that is **offensive**, or whose presence would be **unexpected** or unusual in product of that description".

7.1 Appearance

The Egg Quality Handbook issued by the Queensland Department of Primary Industries' gives a very good summary of the causes and control measures for egg defects that are quality related (Coutts and Wilson, 1990). Copies of the Handbook are available from New Zealand's Egg Producers' Federation.

Table 13: Egg Defects

Shell Defects - Quality	Internal Defects - Quality
Hairline cracks Star cracks Thin-shelled eggs and shell-less eggs Sandpaper or rough shells Misshapen eggs Flat-sided eggs Body-checked eggs (marked by grooves and ridges) Pimples Pinholes Mottled or glassy shells Cage marks **Stained eggs** **Fly marks** **Fungus or mildew on shells.**	**Blood spots** **Meat spots** **Watery whites (indicate staleness)** Pale yolks Mottled yolks and discoloured yolks Discoloured whites **Rotten eggs** **Roundworms in eggs** **Off odours and flavours**

The defects that are in bold in the above table would fall into the definition of wholesomeness under the Animal Products Act 1999:

Possible causes and control measures are clearly explained in the Egg Quality Handbook.

In addition the FSIS, (1999a) says:

- **Blood spots** are caused by a rupture of one or more small blood vessels in the yolk at the time of ovulation. It does not indicate the egg is unsafe.
- A **cloudy white** (Albumen) is a sign of a very fresh egg. A **clear egg white** is an indication that the egg is ageing.
- **Pink** or **iridescent egg white** indicates spoilage due to *Pseudomonas* bacteria. Some of these microorganisms – which produce a greenish fluorescent, water-soluble pigment – are harmful to humans.
- The **yolk colour** varies depending on the hen’s diet. Artificial colour additives are not permitted in eggs (in the USA – but this is not the case in New Zealand).
- A **green ring** on a hard-cooked yolk is a result of overcooking and is caused by sulphur and iron compounds in the egg reaching the yolk’s surface, or by a high amount of iron in the cooking water. The green colour is safe to consume (FSIS, 1999a).

Blood or meat spots are occasionally found on an egg yolk and are merely an error on the part of the hen. They’re caused by the rupture of a blood vessel on the yolk surface when it’s being formed or by a similar accident in the wall of the oviduct. Most eggs with blood spots are detected by electronic spotters and never reach the market. But, even with mass scanners, it’s impossible to catch them all. Both chemically and nutritionally, eggs with blood spots are fit to eat. You can remove the spot with the tip of a knife, if you wish (AEB, 2000).

The twisted, ropey strands of the egg white are the *chalazae* that anchor the yolk in the center of the thick white. They’re composed of nutritious egg albumen and do not indicate contamination. In fact, the more prominent the chalazae, the fresher the egg. These natural parts of the egg don’t interfere with cooking or beating of the white and you don’t need to remove them, although some cooks like to strain them from stirred custard (AEB, 2000).

Blood stained eggs may result from uterine prolapse and vent pecking (Christensen, 1995).

Watery egg whites are found in eggs produced by birds infected with Infectious bronchitis virus and other viral diseases notably EDS 76, (Soft shells more noticeable though). Mallow weed *(Malva parviflora*) does some interesting things to internal eggs – I have seen rubbery pink whites. (Christensen, 2001).

Anecdotal evidence from the industry suggests that New Zealand consumers would also classify the following as wholesomeness issues:

- **Pink** or iridescent egg whites.
- **Soft shells**.
- Eggs that are **older** than their use by date.

7.2 Mould

Mould growth on eggs has been found when egg collection is unduly delayed, or following poor storage and handling (especially when temperature fluctuations result in condensation on the eggs). *Cladosporium herbarum* has been associated with spoilage of eggs when its penetrates the shell’s pores and spreads throughout the interior of the egg (ICMSF, 1998).

Key Messages to New Zealand Egg Producers:

It is important to minimise temperature fluctuations to stop condensation on eggs. This condensation encourages mould growth.

7.3 Pseudomonas

Pseudomonas species are ubiquitous in the environment and water, and some species like cool temperatures. These bacteria are important because they are resistant to most antibiotics and they are capable of surviving in conditions that few other organisms can tolerate. *Pseudomonas aeruginosa* is of clinical significance as an opportunistic pathogen but has rarely been implicated in gastroenteric infection. Other species are significant in food spoilage, particularly in chilled food. Levels higher than 107 cfu/g or ml of food may result in off flavours, off odours and visual defects. The incidence of eggs contaminated with *Pseudomonas* increases with flock age (Bruce and Johnson, 1978). *Pseudomonas* organisms may be related to spoilage of eggs. See section 9.11.3 of the annex for further details.

Key Messages to New Zealand Egg Producers:

Pseudomonas species are likely to be involved in spoilage of eggs.

7.4 Genetic modification

7.4.1 Genetic modification of birds

Currently only traditional animal husbandry and breeding of livestock is used in the egg-laying industry. Cocks and hens are chosen as parents for breeding egg layers based on their positive characteristics - a practice which doesn't involve genetic engineering.

7.4.2 Genetic modification of feed ingredients

The Chief Executive of Crop and Food Research wrote that if a chicken were to be fed with feed that contained modified protein: "any potential danger would come not from the DNA which is present in all living organisms but the proteins which the new DNA (genes) would produce. Protein is rapidly degraded in the gut to amino acids which are the 'building blocks' of proteins. These amino acids are then reassembled by the animal into the proteins that are needed to sustain life. Thus it is extremely unlikely that any GMO-derived protein could survive the digestive process intact and become part of the animal or products such as eggs." (Dunbier, 1999). Research has confirmed that no genetically engineered materials would be passed into the hen's eggs (AEB, 2000).

Key Messages to New Zealand Egg Producers:

Genetic modification is not an issue for New Zealand's egg producers, except that their customers' perceptions of risk may be different to those of the industry.

8. False or Misleading Labelling

Labelling is subject to compliance with the Animal Products Act 1999, the Food Act 1981 and the Fair Trading Act 1986. Claims (e.g. for cage laid, barn laid, free range or organic) must comply with legislation and should not mislead consumers.

When eggs from differing systems are packed off on communal grading equipment, it is easy to get them mixed up.

In June 1999 the New Zealand Consumer magazine reported that many so called "free range" eggs are not laid by hens kept on free range but were instead from caged hens. Some egg cartons for cage laid eggs have pictures on them which imply that the hen can get outside. This is misleading. On March 16, 2001 the New Zealand Press Association reported that a Canterbury farmer was fined $35 000 for labelling cage-laid eggs as free range. The Commerce Commission considered that this was a deliberate deception aimed at falsely achieving the higher price for free-range eggs (NZPA, 2001).

One New Zealand supermarket now only accepts free range, organic and barn eggs that are produced and packed on properties that do not produce other types of eggs. There are two quality assurance schemes operated by Bio-Gro New Zealand and Bio Dynamic Farming and Gardening Association (Demeter) for eggs with claims. Approximately 70% of barn eggs produced in New Zealand are now audited under the "RNZSPCA standards for accreditation of barn egg production". This specifies that accreditation is not available to any producer who has a caged production system on the same property or who packs eggs from both cage and barn systems on the same property (Napier, 2001).

The Egg Producers Federation recommends that those who wish to make claims about the origin of their eggs participate in a credible assurance scheme such as those discussed above.

Food package labelling in New Zealand is further regulated by:
- The Food Regulations 1984
- The Australian Food Standards Code and
- The Australia/New Zealand Food Standards Code.

The latter will phase out the two former statutes in November 2002.

It is recommended that Egg Producers consult the Australia New Zealand Food Standards Code which is freely available at the following web site:
http://www.anzfa.gov.au/draftfoodstandardscode/

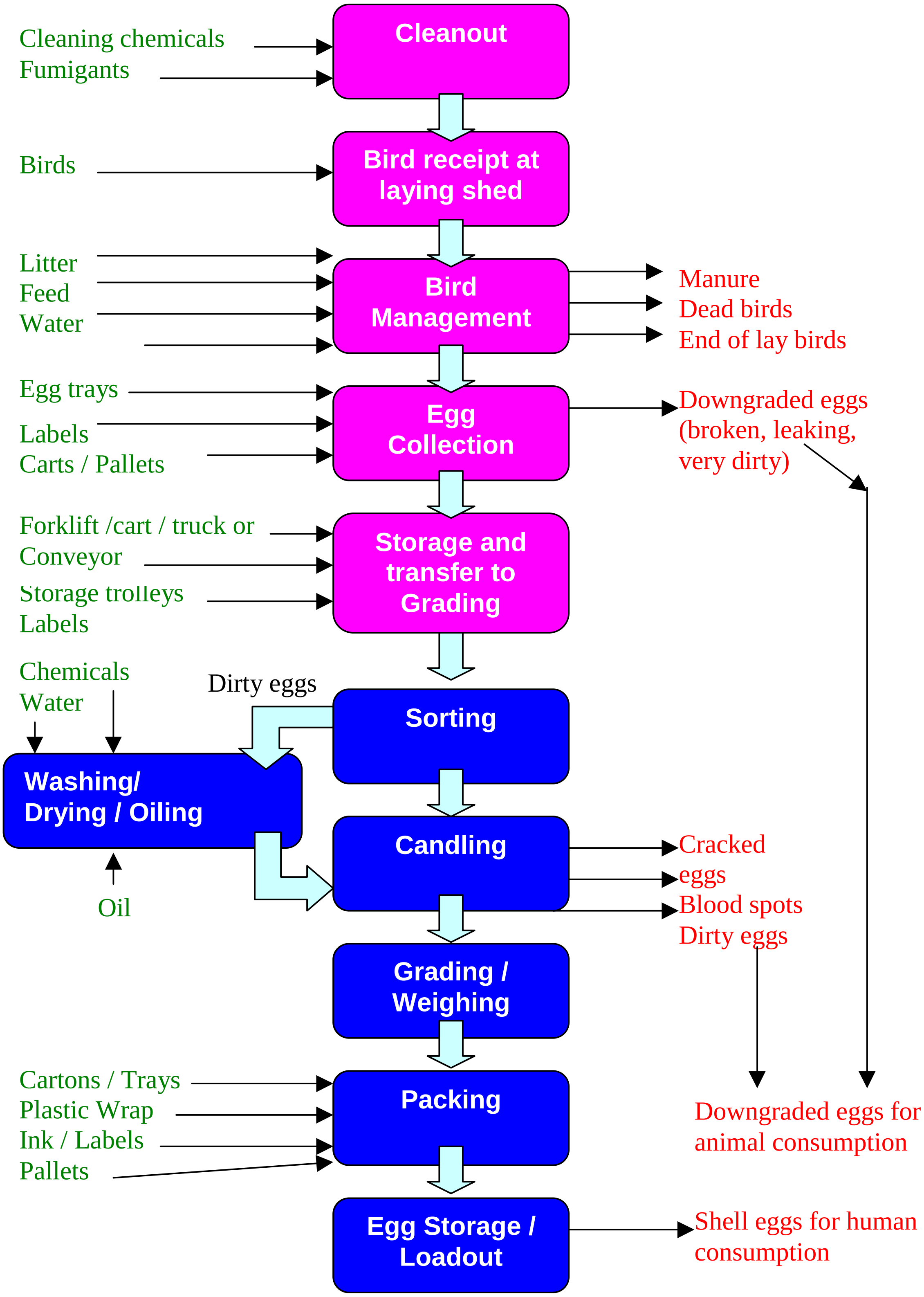
Anecdotal industry evidence suggests that many egg producers recycle packaging and this can result in claims on the original pack not being met by the subsequent user.

Shelf life can be calculated using the guidelines in the Ministry of Health's booklet: "A Guide to Calculating the Shelf Life of Foods – Information Booklet for the Food Industry, 1st Edition, July 1995. It is recommended that egg producers use "Use By" dates on their eggs. Shelf life is achieved by using good handling and storage practices as discussed in section 9 of this annex.

Some eggs that are intended for commercial use are erroneously on-sold for human consumption as shell eggs. The eggs should be clearly labelled to show the intended purpose and to make it clear that they are not intended for sale for resale for human consumption without further processing or cooking.

9. Key Process Steps and Their Inputs: Identification of Hazards and Other Risk Factors and Discussion of Potential Impact of Step on Existing Hazards and other Risk Factors

Figure 3: Egg Production Process



9.1 Cleanout

Before birds are placed in laying sheds there is generally a full clean out (depopulation, litter removal if any, manure removal, dry clean, wet clean, sanitise/disinfection) followed by fumigation to endeavour to rid the shed of any harmful bacteria. If a full depopulation and cleanout has not been done then there is an increased likelihood of contamination to the remaining birds.

Ideally, all birds should be taken for slaughter at the same time - the "all-in, all-out" principle. When the houses are empty, spent litter and faeces must be removed from the farm after which the houses, their equipment and the immediate environment must be thoroughly cleaned and disinfected before re-use. It is also advisable to allow the houses to remain empty for as long as possible to allow a natural die-off of any pathogens present. (SCVPH, 1998). If a full clean is not possible then litter and manure should be removed and a dry clean should be done.

9.1.1 Cleaning Chemicals and Fumigants

Use of unapproved chemicals could leave residues behind on equipment, including that used for feed and water. This may result in traces of residues in water and feed.

9.2 Bird Receipt at Laying Shed

Apparently healthy birds may be carriers of harmful bacteria so laying hens received at the laying shed may bring harmful bacteria in with them. It is possible to reduce the risk of this happening by sourcing laying hens from a supplier who uses good hygienic practices, good biosecurity practices and preferably tests both their birds and feed for *Salmonella*. Birds carrying harmful bacteria may contaminate eggs that they lay, and will also contaminate the environment that they are kept in. If the birds are free range or barn raised there are more opportunities for cross contamination between birds than if they are caged.

Competitive Exclusion (CE) treatment “giving young chicks “good bacteria” is sometimes used to protect chicks against infection by a variety of *Salmonella* serotypes, including both invasive and non-invasive strains. Vaccines can be used to preventing vertical transmission of specific invasive *Salmonella* serotypes. Research has centred on live, attenuated and dead vaccines and some are available commercially. An inactivated vaccine is becoming widely used and aims to reduce vertical and horizontal transmission of *Salmonella* Enteritidis. When parent stock are vaccinated with the preparation, it is claimed that chicks show passive immunity for at least 21 days. As with CE treatment, effective vaccination depends upon the simultaneous use of other control measures, especially a high standard of biosecurity (SCVPH, 1998). Good (i.e. undefined) competitive exclusion (CE) products (Avigard and Broilact) are not available in New Zealand, although Avigard has received biosecurity clearance (Christensen, 2001).

Laying birds should be acquired from flocks that are free from *Salmonella* (Cox *et al*., 1990).

9.3 Bird Management

The following data has on the whole come from overseas reports.

9.3.1 Environment / Manure and Litter

Once *Salmonella* is in a laying shed it can be very difficult to get rid of it, even with very good cleaning procedures. *Salmonella* that persists in the farm environment can spread to incoming flocks. Rodents, insects, birds as well as domestic pets have been suggested as potential sources of *Salmonella* in poultry flocks. Workers and visitors may also contribute as vectors of *Salmonella* contamination from the general environment. (SCVPH, 1998).

Conditions of intensive rearing tend to favour the spread of any pathogens that gain access to the flocks; however, the use of controlled-environment housing for this purpose provides an opportunity to exclude undesirable micro-organisms by maintaining an appropriate level of biosecurity. For *Salmonella*, high standards of personal hygiene are essential and must include proper use of protective clothing, disinfectant footbaths etc. It is also necessary for each farm to exclude biological vectors as far as possible and to implement rodent-baiting programmes. (SCVPH, 1998).

Although attention to husbandry hygiene helps to reduce flock infection with *Campylobacte*r, control of the organism is hampered by lack of knowledge on the sources of flock infection, modes of transmission to poultry flocks and availability of suitable preventive measures. It is clear that animal vectors can play a part, as can farm personnel, if hygiene precautions are inadequate. Vertical transmission seems unlikely because *Campylobacter* shows poor survival in egg contents and newly hatched chicks are invariably free from overt infection. Nevertheless, some evidence suggests that vertical transmission could occur.

It is also useful to control rodents and other vermin, chlorinate the drinking water and effectively disinfect production facilities to disrupt the transmission of *Salmonella* Enteritidis to future flocks (ICMSF, 1998). Mice appear to become infected by *Salmonella* Enteritidis when exposed to contaminated manure. A single mouse can produce 100 droppings a day and if they defecate into feed troughs and on egg belts they can spread the infection to birds and eggs. Rodents can reproduce rapidly in poultry sheds. A few can proliferate to high numbers (up to 10,000 or more) during the life of a single flock (Penn State, 1997). A source from the United Egg producers has been quoted by the UPC as saying, "One rodent can deposit 100 pellets in the course of one night and each pellet can contain 25,000 different *Salmonella* organisms" (Transcript, March 30, 2000, Columbus, Ohio, p. 19). Many of these *Salmonella*-contaminated rodent pellets are deposited in the food troughs and are therefore unavoidably consumed by the hens.

The laying environment can be an important source of salmonellae onto the external surface of the egg. *Salmonella* have been isolated from egg belts, egg collectors, ventilation fans and wash water. Cages, litter and nesting materials should be kept clean and as free of faeces as possible. (ICMSF, 1998).

Flies are potential vectors of foodborne *Salmonella* pathogens. Flies collected at caged-layer facilities that had produced eggs that were implicated as the food vehicle in two recent outbreaks of *Salmonella* Enteritidis infections were tested for Salmonella. *Salmonella* Enteritidis was isolated from houseflies. *Salmonella* Infantis was isolated from houseflies and from dump flies and *Salmonella* Heidelberg from houseflies. *Salmonella* Mbandaka was isolated from a lesser mealworm, *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae). (Olsen and Hammack, 2000).

USA Findings:

Environmental samples were collected from manure, egg belts, elevators, and walkways of 200 layer houses and tested for *Salmonella* Enteritidis. It was found in environmental samples in 7% of layer houses, and NAHMS estimated regional prevalence ranging from 0 to 17%. 4% of house mice collected in 129 of the layer houses were also positive. The prevalence of SE in mice from environmentally positive houses was nearly four times that of mice from environmentally negative houses (Anonymous, 2000).

Other highlights:

- 17 environmental samples were collected from each of 200 layer houses for culture. SE was found in 7.1% of layer houses.
- Flocks less than 60 weeks of age were 4.7 times more likely to test positive than older, unmoulted flocks. Flocks that were 0-16 weeks post-molting were 9.3 times more likely to test positive compared to flocks that were 60 or more weeks of age and unmoulted, but flocks more than 16 weeks post-molt had very little increased risk.
- None of the houses tested positive for SE on farms where the feeders or hoppers were cleaned and disinfected between each flock or where cages, walls, and ceilings were washed between each flock, whether or not they were fumigated.
- Houses with a high rodent index were more likely to have SE found within the house than houses with a low rodent index.
- Overall, 3.7% of house mice cultured were positive for SE.
- Only 15.7% of farm sites routinely tested for SE in 1994, whereas 58.0% of farm sites routinely tested for SE in 1999. (Anonymous, 2000).

9.3.2 Feed

Various surveys have identified feed as an important source of *Salmonella* for the farm. . Successful control of *Salmonella* on the farm is dependent on a consistent supply of *Salmonella*-free feed. Although raw materials used for preparation of feed may harbour the pathogen, pelleting, heating and other specific treatments are generally successful in eliminating *Salmonella*. However, the final feed may be contaminated because of an insufficient heating process or to recontamination in the feed mill, during transport or during storage at the farm. Measures taken at feed mills to safeguard the final product include the use of a heating process, sometimes combined with chemical treatment of the feed, and care to prevent recontamination during cooling. Short-chain fatty acids, such as formic and propionic acids, may be incorporated in feed and have the advantage of protecting it against recontamination during distribution and storage. The acids can reduce the incidence of *Salmonella* infections in poultry but are active only when the feed is moistened following consumption by the birds. Acids have no beneficial effect once the birds have become infected. (SCVPH, 1998).

Feed, on the other hand, is too dry to favour survival of Campylobacter and is not regarded as a source of campylobacter infection. (SCVPH, 1998). Feed should be kept dry during storage and delivery to the birds. If there is any chance feed can get wet (e.g. free range birds) then it should be fed in quantities so that all feed is consumed daily to minimise the likelihood of mould growth. This will also discourage rodents and wild birds somewhat. (Christensen, 1995).

New Zealand Situation

The New Zealand Code of Good Manufacturing Practice for Compound Feeds, Premixes and Dietary Supplements, March 2000, was approved by the Director-General, MAF, as being compliant with the ACVM Standard for Codes of Practice. This voluntary code is an appropriate manufacturing guide for the industry, and if implemented should address the critical control points in the production of compound feed, premixes and dietary supplements from the purchasing of ingredients through to the sale of the finished product. The code is designed to enhance both product quality and consumer protection.

A survey of NZ egg producers has found that *Salmonella* is occasionally found in feed.

9.3.3 Drinking Water

Contaminated water can be a source of foodborne pathogens, including *Salmonella* when it is dispensed in open troughs that can become contaminated by dust, litter, feed, feathers and faeces. (SCVPH, 1998).

There is a possibility that untreated water-supplies can transmit the organisms and, if mains water is not available, the supply to the growing houses should be chlorinated. Since campylobacters survive well in biofilms, thorough cleaning and disinfection of the water-supply system in each house is essential between different crops of birds. (SCVPH, 1998).

A survey on microbiological testing done by 15 New Zealand egg producers showed that only one had tested the drinking water and their results indicated that there may have been an issue with faecal coliforms and *E. coli* which were found to be present in some samples.

The Codes or Recommendations and Minimum Standards for the Welfare of Layer Hens (AWAC, 1999) states:
"10.1.1 Hens must be offered a continuously available supply of potable water…
10.1.3 All water should be tested for salt content and microbiological contamination and advice obtained on its suitability for poultry…"

A supermarket Code of Practice that some egg suppliers have been operating to require drinking water to meet the NZ Drinking water microbiological standards, with water at point of use checked at least once a year.

9.4 Forced moulting

Forced moulting is the process of reducing feed and /or water for a specified period to induce moulting, which also gets another laying cycle out of a hen. It usually results in lower production volumes, lower egg quality and a shorter laying cycle. There can also be animal welfare issues if the forced moulting is not properly managed.

9.4.1 New Zealand Situation

Moult inducement and controlled feeding may only legally be done in accordance with the Code of Recommendations and Minimum Standards for the Welfare of Layer Hens issued in November 1999 by AWAC (Animal Welfare Advisory Committee). It states:

"13.4.1 Moult inducement or controlled feeding practices should only be carried out on healthy hens under close management supervision and under conditions that will not cause cold stress. Substitution of a high fibre diet, (for example, whole barley), in place of normal rations is a preferred method of moult inducement. Adequate feeding space should be provided during such practices.

13.4.2 Methods of moult inducement and controlled feeding which totally deprive hens of food or water for more than 48 hours must not be used."

9.4.2 Overseas Situation

Forced molting (starving hens for 5 to 14 or more days) is illegal in the UK and the European Union, and is not done in Canada. US Department of Agriculture studies have shown that the "traumatic physiological impact" of total food removal results in a significant increase in *Salmonella* infected hens and eggs. While unmoulted hens have to ingest 50,000 Salmonellae to become infected, force-molted hens need fewer than 10. (UPC, 2000)

The USDA and Pennsylvania Department of Agriculture conducted field studies of 31 flocks from May 1992 to May 1994 which showed that molted flocks "produced SE-positive eggs twice as frequently as non-molted flocks for a period up to 140 days"-4 1/2 months-following the forced molt. (UPC, 2000)

In California a bill is being introduced to ban forced moulting (currently used on 95% of California's 25 million laying hens). This practice of withdrawing all food from hens for 10-14 days disrupts the hens natural immunity predisposing them to *Salmonella* infestation (Wade, 2000).

There is a cause and effect relationship between forced molting and *Salmonella* Enteritidis in eggs (UPC, 2000a). USDA immunologist Peter Holt and his colleagues published a series of Agricultural Research Service studies between 1992 and 1996 in which they found that depriving hens of sustenance causes immune suppression, thereby predisposing the birds to SE invasion, colonization and migration.

A USDA Risk Assessment predicted that human *Salmonella* Enteritidis infections could be "reduced by 2.1 percent if forced molting were eliminated. USDA's Food Safety and Inspection Service wrote: "FSIS recognises that public health concerns are raised by highly stressful forced molting practices. For example, extended starvation and water deprivation practices lead to increased shedding of *Salmonella* Enteritidis by laying hens subjected to these practices" (UPC, 2000a).

USDA's Food Safety and Inspection Service has agreed that there is epidemiological evidence associating forced molting with higher prevalence of *Salmonella* Enteritidis in flocks. Experimentally, Holt *et al*. (1996, 1995, 1994, 1993, 1992) have demonstrated that molting is associated with increased numbers of SE in hens intestinal tracts, and higher rates of SE-positive eggs are produced following [the forced] molt. (*Salmonella* Enteritidis Risk Assessment Team, 1998).

"Stress situations can reactivate a previous infection. . . . and feed withdrawal to induce a molt can also cause the recurrence of a previous *Salmonella* Enteritidis infection". "Recrudescence of infection was observed significantly more often in molted birds. These birds shed significantly more *Salmonella* Enteritidis and more readily transmitted the organism to previously uninfected, but contact-exposed hens". "The molted hens also produced more eggs contaminated with the organism".

It is significant that an intestinal microorganism like *Salmonella* has evolved a serotype *Salmonella* Enteritidis that thrives in the ovaries and oviducts of hens where their eggs are formed, thereby precontaminating the interiors of intact eggs. According to the Centers for Disease Control, "The specific serotype *Salmonella* Enteritidis can live in the intestinal tract, but it also can infect the ovaries and oviducts of egg-laying hens. It is not known why this is an increasing problem. It is possible that this bacterial strain has become more invasive, or that hens have less resistance, or that some change in poultry husbandry permitted this strain to become more widespread" (CDC Record, June 8, 1990, .p. 2; see also p. 12 of the Transcript of the April 6 Public Meeting in Sacramento, California) (UPC, 2000a).

Key Messages to New Zealand Egg Producers:

The forced moulting practices that are sometimes used overseas are not in accordance with the New Zealand's current Code of Recommendations and Minimum Standards for the Welfare of Layer Hens. This code is a "deemed" code under the Animal Welfare Act 1999, which makes it legally binding. For this reason the arguments put forward overseas cannot be directly applied in New Zealand, but they do raise awareness of a possible increase in shedding of pathogenic bacteria should these recommendations not be followed.

9.5 Laying

9.5.1 NZ Situation (Data provided by Egg Producers Federation).

Of the estimated 2,700,000 layers currently in production in New Zealand, an estimated 93% are in cage systems, 2% in barns and 5% on free range.

Caged Systems

Approximately 70% of the caged layers use multi-layer cage units, mainly installed in the last 5-6 years with automated collection systems conveying eggs directly to an egg grader. Eggs are produced, conveyed, graded and packed without human handling except for the removal of undergrades, and are therefore least exposed to hazards associated with more manual systems.

Manure is automatically removed every few days, and substantially reduces rodent and fly build-up that may present additional hazards.

With multi-aged flocks in these systems, care should be taken to minimise any cross contamination between flocks of different ages. Sheds are rarely, if ever, empty so additional care is required at cleanout following removal of spent layers.

The remainder (30%) of caged layers use semi-automated or manual egg collection systems which rely on placing eggs in trays (usually plastic) for subsequent transport to a grading facility. Depending on the time taken between collection, transportation and grading sometimes an intermediate cool room is required.

Advantages	Disadvantages
• Easy to control environment eg temperature, feed, water and light • Space restriction suppresses hen aggression • Small hen colony size • Good disease control • No threat from predators	• Lack of space/facilities prevents certain normal behaviour eg dust bathing • Cage structure may cause feather and foot damage • Confinement leads to weak bones and bone breakages

Barn Systems

Of the barn systems (2% of production), approximately 55% of the eggs are conveyed directly to the grader, with the balance being packed for subsequent grading. Layers are in direct contact with the ground, litter, and their own and other birds' faeces. The risk of contamination from these sources is greater than in caged systems.

Advantages	Disadvantages
• Varied physical environment where normal behaviour can be expressed • Protection against predators • Freedom to move within the hen house • Provision of nest boxes, perches and dust bathing facilities • Improved bone strength due to increased activity • Birds can escape aggression by moving within the hen house	• Beak trimming may be required to prevent bird aggression such as feather pecking and cannibalism • Management of waste droppings more difficult • Hens can be injured by falling between perches at different levels • Floor eggs will be dirtier than nest eggs and should not be sold as first grade eggs • Increased risks of parasites

Free Range Systems

At the time of publication, all egg collection systems on free range production facilities are manual, i.e. none provide an automated "on line" collection and grading system. Free range layers have direct access to outside so are likely to be exposed to a wider range of bacteria and parasites from natural waterways, wild birds, contaminated pasture and soil, than layers kept in other systems. Ducks and wild fowl are known reservoirs of harmful bacteria so free range areas near to the water fowl habitat should be avoided when providing free range areas. Free range hens may also have access to poisons intended to control pests.

This is particularly likely if there is no set rotational pasture system in place. Like barn kept birds, free range birds are in direct contact with the ground, litter, and their own and other birds' faeces. The risk of contamination is therefore greater for free range systems than for either caged or barn systems.

Birds placed on free range units will be at risk from worm infestation. The worm eggs are difficult to kill and may survive in the soil for up to one year. The best methods to control the worm eggs are paddock rotation and harrowing the pasture to expose the worm eggs to sunlight, lethal to the worm eggs. Worm egg populations are seasonal since they favour warm, wet conditions. Keeping pastures short or grazed through the year will reduce the survival time of worm eggs. Good hygiene will reduce the spread of infestation. It is advisable to routinely check for worms through taking representative dropping samples 2 or 3 times during a flocks life. This is a simple test and can be carried out by any veterinary practice. (A representative sample would be a pot containing 40-50 faeces).

If hens are suffering from diarrhoea the nest boxes are likely to become soiled and there is a much greater chance of faecal soiling of the egg. In these circumstances, frequent changes of the next box litter is necessary until the condition is brought under control. (Christensen, 1995).

Advantages	Disadvantages
• Freedom to move freely and express wide range of behaviour • Opportunity to graze on vegetation and varied diet • Opportunity to dust bathe in soil • Improved bone strength due to increased activity	• Beak trimming essential to prevent bird aggression such as feather pecking and cannibalism because of large flock sizes • Risk of predators • Disease risk due to access to droppings and contact with wild birds • Increased risk of respiratory problems • Adverse climate outside • Floor eggs will be dirtier than nest eggs and should not be sold as first grade eggs • Increased risks of parasites / worms

9.5.2 Overseas Situation

The European Union has banned battery cages for welfare reasons in member countries after 2012. No new battery cages may be installed after 2003. After 2012 all hens must have at least 750sqcm of space, a perch, a nest, and litter to scratch and peck.

Key Messages to New Zealand Egg Producers:

It is expected that the number of free range and barn operations will also rise in New Zealand. If this is so, extra care will be needed to protect the hens from contamination wherever possible.

9.6 Egg Collection / Holding / TRANSFER TO GRADING

9.6.1 New Zealand Situation

Egg collection methods in New Zealand include both automatic conveyor collection and manual systems as described in 9.5.1. The Egg Producer's Federation recommends that eggs are collected at least every 24 hours, and more frequently if possible.

Plastic trays used for egg collection are usually recycled. There is a possibility that dirty trays could contaminate eggs that are placed in them. Some eggs are held at room temperature until moved to the grading facility. This could allow growth of any pathogens that are present.

In manual collection systems the eggs are often pre-sorted to separate out badly soiled or cracked eggs from the others.

Various methods are used in the industry to transfer the eggs to the grading facility – often dependent on the distance. These include by truck, trolley, automatic conveyor, forklift etc.

9.6.2 Overseas Situation

The earlier that eggs are collected after laying, the lower is the rate of contamination of the shell with microorganisms (North, 1984).

In the USA studies have shown that temperature abuse, i.e. holding eggs and foods containing raw egg at room temperature instead of under refrigeration, is a common factor in SE outbreaks (USDA, 1999c).

Pathogen growth can occur due to inadequate holding temperature and relative humidity (CFIA, 1998).

The Australian Code of Practice States that eggs shall be collected at least once a day and stored and transported below 20°C.

Key Messages to New Zealand Egg Producers:

The frequency of egg collection recommended overseas would currently be more frequent than that used by some of New Zealand's small operations. New Zealand's Egg producers Federation recommends that eggs are collected at least every 24 hours, and more frequently if possible.

9.7 Dry Cleaning

Eggs can be dry cleaned, e.g. using a stiff brush, sandpaper or steel wool, or washed. Mechanical dry cleaners may themselves be difficult to clean and may actually be a source of contamination. Dry cleaning removes the cuticle, thereby reducing the egg's protective barriers. The egg is more susceptible to microbial penetration when wet. Dry cleaning may force microorganisms from the surface of the egg into the shell's pores – actually making the situation worse. If eggs are stored under proper humidity control dry cleaning can be as effective as washing the eggs (ICMSF, 1998).

When dirty eggs are cleaned with abrasives, the cuticle is damaged. Any damage may allow entry of microorganisms. The cuticle is however fairly resistant to water, detergents, or gentle rubbing with a cloth. (Baker, 1974).

Specification 107(2) of New Zealand's Animal Products (Specifications for Products Intended for Human Consumption) Notice 2000 states: "Any primary processing of eggs intended to be traded in the shell that compromises the integrity of the shell, must be minimised." Dry cleaning is a process that would fall into this category.

Key Messages to New Zealand Egg Producers:

Dry cleaning should be avoided.

9.8 Washing / Drying / Oiling

Pathogens can survive in wash water due to inadequate control of temperature and/or pH, and insufficient changes of wash water. Contamination can also occur due to dirty water and brushes. Pathogens can contaminate eggs during drying if there are dirty air filters. An ineffective or inoperative dryer can result in eggs not being properly dried. Pathogens can also be transferred to the eggs from bacterial growth on oiling brushes. (CFIA, 1998).

9.8.1 NZ Situation

Some egg producers do wash eggs in New Zealand. The Food Regulations 1984, 131 (4) states: "Subject to subclause (5) of this regulation, eggs may be cleaned and oiled with edible oils or mineral oils" and subclause (5) states: "No person shall use, or permit to be used, any process or appliance for or in connection with the cleaning and oiling of eggs, unless that process has been approved for that purpose, within the preceding 12 months, by an Officer." Clause 132 of the same Regulations states: "Eggs for sale that have been preserved by the application of any substance, other than edible oils, that seals the pores of the shells shall be stamped on the shells in indelible ink, in 2 mm lettering, with the word "preserved".

9.8.2 Overseas Situation

Cleaning of eggs is required in the United States and Canada, presumably to reduce the risk of pathogenic bacteria penetrating the egg. There are conflicting studies that show that there is a greater rate of spoilage after cleaning due to increased penetration by bacteria (ICMSF,1998).

The following factors related to washing affect microbial penetration and spoilage (Stadelman, 1994):

- Washing eggs in liquid that is at a lower temperature than the eggs results in liquid (plus any bacteria in it) being drawn through the pores. The temperature of the liquid should be at least 12°C higher than the temperature of the eggs.
- Visibly dirty eggs tend to have a higher spoilage rate than those that are clean.
- Any process that wets the shell increases spoilage.
- Damage to the cuticle results in increased microbial penetration.
- Wash water containing iron increases the iron level in the albumen, neutralising the antimicrobial affect of conalbumin. Wash water should have less than 2ppm Fe(III). Levels above 5ppm may greatly accelerate spoilage and growth of pathogens.
- The use of potable water, disinfectants or alkaline detergents reduces the microbiological impact of washing.

Washing recommendations (ICMSF, 1998):

- Only fresh, intact eggs that have been ideally cooled to 10-14°C should be washed. This helps to achieve the desired temperature differential between the egg and the wash water.
- Washing should take place as soon as possible after collection as washing will not remove bacteria that have already had time to penetrate the egg.
- Jets of wash water and/or brushes should have complete access to each egg.
- The washing temperature should be 40-42°C (higher may risk cuticle damage).
- Wash water should be purified or filtered to remove organic matter and the microbes.
- The detergent used should be alkaline (capable of raising the pH of the wash water to 10-11) as acid detergents attack the shell.
- Detergent should be low foaming and improve the dirt removing efficiency of the water.
- A final rinse with clean water containing a sanitiser should be applied, e.g. 100-200 ppm of chlorine, quaternary ammonium compounds or calcium hypochlorite, or 12-25 ppm iodine. A potable water final rinse is required when iodine is used. Iodophors or chlorine-bromine compounds have also been found to be effective. The temperature of the rinse water should always be slightly higher than the wash water, e.g. 43-45°C.
- If the washing machine recirculates the hot, detergent/sanitiser-treated water then care should be taken to ensure that the organic and microbiological loading does not increase to unacceptable levels. This is usually done through filtration and periodic water changes (at least daily and more frequently if required).
- Immediately after washing is completed the eggs should be dried quickly and completely to reduce the risk of any remaining bacteria being aspirated into the egg.
- Drying should be followed by candling where any cracked eggs must be removed.
- Some countries permit the use of mineral oil (paraffin oil) sprays to protect the egg from water loss and the associated increase in air cell volume during cold storage. This protects the egg to some extent from bacterial penetration. Some other coatings have also been trialled successfully, e.g. alginates, polymethacrylic acid, corn promaline, polyvinyldene chloride, hydrolysed sugar derivative.

Pathogen survival increases if the wash water temperature and the pH is too low, i.e. 32-35°C, or 9-10 respectively. Cross contamination by *Salmonella* Enteritidis has been observed when the wash water had a pH of 9 but not at 11. *Yersinia enterocolitica* and *Listeria monocytogenes* have both been isolated from wash water (ICMSF, 1998).

The Canadian Food Inspection Agency's HACCP generic Model of 1998 recommends that wash water is at least 40°C and at a minimum pH of 10.5 under normal conditions (CFIA, 1998).

Key Messages to New Zealand Egg Producers:

The above details show that washing should only be carried out if it can be carefully controlled and in accordance with above guidelines.

9.9 SORTING / Candling / Grading

Badly cracked and soiled eggs are usually removed from the conveyor belt prior to candling and grading.

Failure to remove excessively dirty and/or leaking eggs can result in cross contamination of equipment, wash water (if used) and other eggs (CFIA, 1998).

Eggs should be candled using white light and black light candlers. This enables the operator to identify and remove spoiled, leaking or otherwise unacceptable eggs. This includes cracked eggs and those with punctured yolks.

Returned eggs coming back from customers should be sent for further processing.

Eggs should be put into one of the following categories:

A grade shell eggs = eggs without visible cracks or internal defects so are suitable for retail sale for human consumption.

Commercial eggs = eggs without visible cracks, but may have size/shape abnormalities or other minor defects that do not compromise egg safety or wholesomeness – not for retail sale in shell but still suitable for human consumption. These eggs are normally sold for catering or other similar uses.

Cracked eggs = eggs that can be sent for further processing (Pasteurisation or equivalent) or for animal consumption.

Reject eggs = eggs unsuitable for human or animal consumption.

9.10 Packing / LABELLING

Most labels are printed on the pack or attached to the pack at this time. It is important to check that the eggs that are being packed match the label at this step.

The Egg Producers Federation recommends that egg packhouses ensure that they can trace eggs so that they can at least identify which farms' eggs were packed on each day.

Anecdotal evidence from the New Zealand industry suggests that some product packaging is recycled. It is possible that eggs could be contaminated by dirty packaging. The Egg Producer's Federation recommends that recycling of packaging is not practised for A grade eggs.

9.11 Storage

9.11.1 New Zealand Situation

A supermarket Code of Practice requires eggs to be held at 15°C with a shelf life of 30 days – mainly for quality reasons (to get the right Haugh units).

The current Egg Producers' Federation Code Of Practice recommends eggs be held at 15°C with a maximum Best Before date of 35 days from date of lay. There have been no known problems associated with this regime.

It is therefore recommended that eggs should only be stored out of direct sunlight, in a temperature controlled environment, at or below 15°C, and once subject to temperature control, this should be maintained (including during transportation) with minimal fluctuations until the egg producer relinquishes control of the eggs.

Eggs that have been graded as suitable for "further processing" only (cracks) must be stored as either whole, or split into satisfactory containers, and stored at 4°C or below. These eggs must then be "processed" within 3 days (except that if these splits have been frozen then time is not an issue). All these products must be clearly dated and labelled, e.g. "EGGS FOR PROCESSING ONLY. NOT FOR RESALE."

9.11.2 Impact of Storage Conditions on Pathogenic Organisms – Overseas Data

Studies have shown that older eggs are more likely to be contaminated with enough bacteria, including *Salmonella*, to cause food-borne illnesses (Hagenbauch, 1999). *Salmonella* numbers per egg rise after storage of eggs at ambient temperature (Clay and Board, 1991; Humphrey and Whitehead, 1992). This is likely to be due to the defence mechanisms of the egg deteriorating over time.

The age of the yolk was found to be a principal factor controlling the growth of *Salmonella* Enteritidis by Humphrey and Whitehead (1993). Growth rates were more rapid in eggs that were 21 days or older. Storage temperature fluctuations were also found to facilitate the growth of *Salmonella* Enteritidis.

Eggs are stored with the blunt end up to keep the yolk from drifting towards the inner membrane. If this were to happen, any microorganisms that penetrate the membrane could bypass the protective barriers in the white and directly contaminate the yolk, resulting in rapid spoilage (Board, 1964; Brown *et al.,* 1970).

Storage temperatures below 8°C inhibit the growth of bacteria. At temperatures up to 18°C the egg's antimicrobial barriers degrade slowly, but the degradation accelerates at temperatures over 18°C (ICMSF, 1998).

Cold-stored eggs that are submitted to warmer, moist conditions can be subject to condensation. If these eggs are returned to the cooler temperature while they are still wet then surface bacteria can be aspirated into the egg as the air sac contracts (ICMSF, 1998). The relative humidity during storage should be between 70 and 85% (Henderson and Lorenz, 1951). Below 70%, the quality is affected by the rapid weight loss through evaporation. Above 85%, microbial penetration is enhanced and moulds may grow.

Bradshaw *et al* (1990) found that when *Salmonella* Enteritidis was injected into the yolk of eggs from normal and seropositive hens, and the eggs were then stored at different temperatures, the generation time for bacterial growth also varied. In normal yolk, it was 25 minutes at 37˚C and 3.5 hours at 15.5˚C. In yolk from seropositive hens the generation time was 35 minutes at 37˚C.

Eggs can be infected with *Salmonella* Enteritidis internally or externally at lay, or can become contaminated after lay. The principal site of contamination of the egg contents appears to be either the outside of the yolk membrane or the albumen surrounding it. The yolk membrane becomes more permeable during storage and multiplication of these organisms can occur when eggs are stored above 20°C, or kept for more than 3 weeks. In 1993 the Government's Advisory Committee on the Microbiological Safety of Food (ACMSF) recommended that eggs should be maintained at a temperature below 20°C and consumed within 21 days (British Egg Information Service, 1999).

A 12% reduction in human illnesses was predicted by a risk assessment model if all eggs are immediately cooled after lay to an internal temperature of 45°F (7.2°C), then maintained at this temperature throughout shell egg processing and distribution. If the temperature controls start at processing then an 8% reduction in illnesses is predicted. (*Salmonella* Enteritidis Risk Assessment Team, 1998). These figures were based on the fact that there is an inherent delay in the growth of *Salmonella* Enteritidis of 11 days at an internal egg temperature of 45°F (7.2°C), or 30 days at an internal egg temperature of 60°F (16°C). It is critical that the internal temperature of the egg is reduced to 45°F (7.2°C) before the inherent resistance to yolk membrane breakdown is exhausted.

T.J. Humphrey found that in eggs artificially inoculated with *Salmonella*, no growth was observed after 3 weeks at 8˚C, but growth was observed at 10, 12 and 15˚C. Bradshaw *et al* observed no significant growth when eggs with inoculated yolks were held at 7˚C for up to 94 days. On reviewing the above articles the FDA stated "the scientific evidence on the growth of *Salmonella* Enteritidis in eggs shows that control of the storage temperature of shell eggs can effectively prevent the multiplication of any *Salmonella* Enteritidis that may be present.

While there is some debate about the optimum storage temperature for eggs, the research…indicates that refrigerating shell eggs at 8˚C and 7.2˚C or less greatly extends the time that an egg can maintain its defenses against movment of contaminating bacteria such as *Salmonella* to the nutrient rich yolk, and, therefore, substantially reduces the likelihood that any *Salmonella* Enteritidis that is present will be able to increase in numbers. Moreover there is evidence that cooling eggs reduces the heat resistance of *Salmonella* Enteritidis microorganisms, making any microorganisms that may be present in an egg more likely to be killed when the egg is less than completely cooked." (FDA, 1999).

The Canadian Food Inspection Agency's HACCP generic Model recommends that ungraded eggs are stored at or below 13˚C prior to washing, and that graded product be stored at or below 7˚C to control the growth of *Salmonella* Enteritidis if it is present (CFIA, 1998).

C. J. Kim *et al* (1989) found that temperature was the most important determinant in the growth of *Salmonella* Enteritidis in infected eggs, and that the growth response was directly proportional to the temperature at which the inoculated eggs were held. They found that even with low numbers of *Salmonella* Enteritidis originally inoculated into the albumen, temperatures of 10˚C or higher for up to 30 days allowed numbers to multiply to substantial levels.

Bacteria, if they are present at all, are most likely to be in the white and will be unable to grow, mostly due to lack of nutrients. As the egg ages, however, the white thins and the yolk membrane weakens. This makes it possible for bacteria to reach the nutrient-dense yolk where they can grow over time if the egg is kept at warm temperatures. But, in a clean, uncracked, fresh shell egg, internal contamination occurs only rarely (AEB, 2000). Egg quality is tied to three things: time, transport and temperature. Egg quality deteriorates slowly at 5°C but rapidly at 25°C. Eggs should be held at the right temperature as soon as possible as egg quality is noticeably reduced if they are first held at room temperature for 1-2 weeks. Variations in temperature (greater than 2 degrees C) have a particularly adverse affect on quality (Anonymous, 1959).

Salmonella Enteritidis can cause mortality in young chicks, but rarely causes clinical disease in adult birds. It has the ability to infect internal organs, including the ovaries and oviduct (ACMSF, 1993). It has a generation time of approximately 30 minutes at 37°C, 3.5 hours at 15.5°C, and no multiplication after 94 days at 7-8°C. Storage at 20°C restricted growth until the 21st day (Humphrey, 1994). Storage at room temperature did not affect the incidence of *Salmonella* contamination, but those eggs held for more than 21 days were more likely to be heavily contaminated. The ACMSF (1993) concluded that the normal antimicrobial barriers in shell eggs are sufficient to control *Salmonella* Enteritidis growth as long as eggs are less than 21 days old and the temperature has not exceeded 20°C. If either condition is exceeded then eggs should be stored at not more than 8°C.

Freshly laid eggs have a pH of 7.6-7.8. After 1-3 days at room temperature the pH of the egg white increases to 9.1-9.6 due to the loss of carbon dioxide (Board, 1969). Bacteria that penetrate the shell may be able to multiply inside the egg after storage. It is recommended that eggs are stored at 10°C or below to prevent multiplication of *Salmonella* (Clay and Board, 1991; Dolman J. and Board, 1992). The Australian Code of Practice recommends that eggs are stored "below 20°C at the farm, during transport and at the retail outlet, in conditions which avoid surface condensation or contamination" (AEIA, 2001).

Figure 4: Changes Occurring In Infertile Eggs During Storage

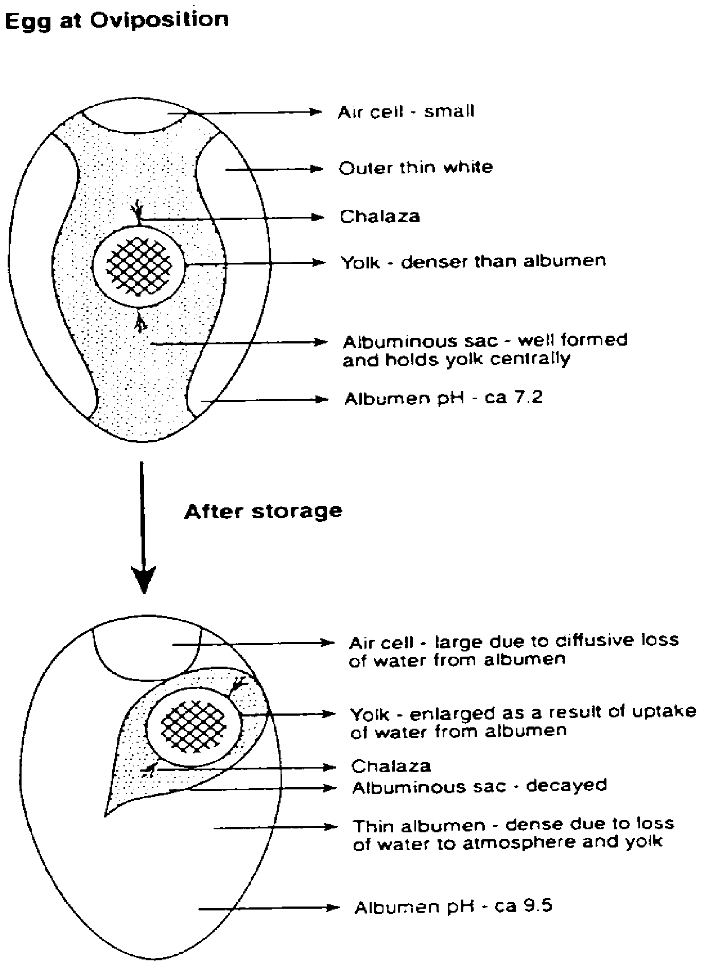


FIGURE 8.6. Changes occurring in infertile eggs during storage, which, by the end of 10–15 days, allow the bacteria present on the membranes to multiply in the egg. (Reproduced by kind permission of Professor R. G. Board.)

Figure ex (Mossel *et al*, 1995)

Key Messages to New Zealand Egg Producers:

Countries that have a *Salmonella* Enteritidis problem associated with eggs have required more stringent refrigeration regimes than is currently the case in New Zealand. If this bacteria becomes a problem in the New Zealand industry then these refrigeration requirements should be considered.

Figure 5: Changes in Quality As the Egg Ages

Changes in quality as the egg ages

Changes in quality as the egg ages are summarised in figure 2. To slow down these changes, new-laid eggs can be put in cool storage, and/or the shells covered in a thin layer of an approved oil, particularly over the air cells.

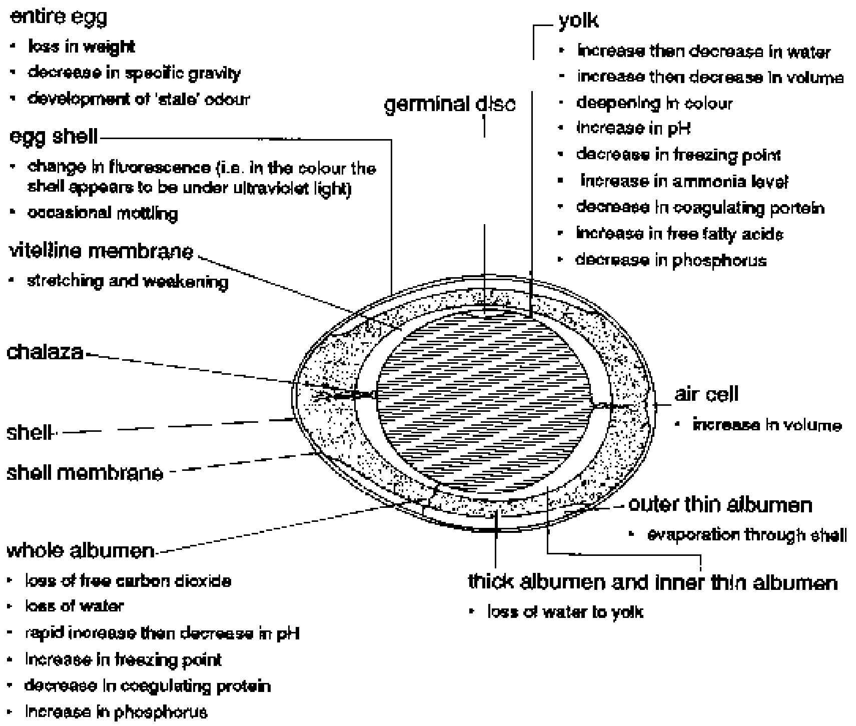


Figure 2 Structure of the egg. A summary is given of the changes occurring as the egg ages.

Figure ex Egg Quality Handbook, Coutts and Wilson, 1990, page 4.

9.11.3 Impact of Storage Conditions on Spoilage Organisms – Overseas Data

When properly handled and stored, eggs rarely spoil. As an egg ages, the white becomes thinner, the yolk becomes flatter and the yolk membrane weakens. These changes may affect appearance, but they don't indicate spoilage and don't have any great effect on the nutritional or baking quality of the egg (AEB, 2000).

Chilled storage minimises but does not prevent bacterial spoilage of eggs (which can result in rotten eggs) and is usually caused by *Pseudomonas* spp., *Acinetobacter, Moraxella, Alcaligenes* and Enterobacteriaceae e.g. *Enterobacter, Proteus, Escherichia* and *Serratia* spp.

The following table gives a good indication of microorganisms that are likely to cause spoilage.

Table 14: Microflora On The Eggshell And Within Spoiled Eggs

Type of microorganism	Frequency of occurrence[a]	
	On the shell	In rotten eggs
Micrococcus	+ + +	+
Escherichia, Pseudomonas, Alcaligenes	+ +	+ + +
Arthrobacter, Bacillus, Cytophaga, Achromobacter, Flavobacterium	+ +	+
Enterobacter, Staphylococcus	+ +	-
Proteus	+	+ + +
Aeromonas	+	+ +
Streptococcus	+	+
Sarcina, Serratia	+	-

[a] No. Of plus signs indicates relative frequency of occurrence.
Adapted from Mayes and Takeballi, 1983, as adapted from Bruce and Drysdale, 1994.

Like all natural organic matter, eggs can eventually spoil through the action of spoilage organisms, which although unpleasant, don't cause foodborne illness. The bacteria *Streptococcus*, *Staphylococcus*, *Micrococcus* and *Bacillus* may be found on egg shell surfaces because all these species can tolerate dry conditions. As the egg ages, though, these bacteria decline and are replaced by spoilage bacteria, such as coliform and *Flavobacterium*, but the most common are several types of *Pseudomonas*. *Pseudomonas* can grow at temperatures just above refrigeration and below room temperatures and, if they're present in large numbers, may give eggs a sour or fruity odor and a blue-green coloring (AEB, 2000).

Although it is more likely for bacteria to cause spoilage during storage, mold growth can occur under very humid storage conditions or if eggs are washed in dirty water. Molds such as *Penicillum*, *Alternaria* and *Rhizopus* may be visible as spots on the shell and can penetrate the shell to reach the egg (AEB, 2000).

Discard any eggs with shells that don't look or feel clean, normally colored and dry. A slimy feel can indicate bacterial growth and, regardless of color, powdery spots that come off on your hand may indicate mold (AEB, 2000).

Key Messages to New Zealand Egg Producers:

Minimising the environmental contamination of eggs, and handling and refrigerating them properly will reduce the likelihood of spoilage of the eggs. The Egg Producers Federation of New Zealand recommends eggs be held at 15°C with a maximum Best Before date of 35 days from date of lay.

9.12 Loadout and Delivery

Loadout and delivery can be considered to be a continuum of storage. See 9.11.

9.13 Consumer Information

Occasionally, even in New Zealand where *Salmonella* Enteritidis is not a major issue, eggs with clean, uncracked shells can be contaminated with bacteria. If foods containing harmful bacteria are consumed, they can cause food-borne illness. The risk is very low, but the consumer can minimise the risk further by following the recommendations of the American Egg Board as summarised below.

At the supermarket, select perishable foods last and separate raw meat, fish, seafood and poultry from eggs and other foods in your grocery cart. At home, refrigerate raw shell eggs in their cartons in the coldest part of the refrigerator, away from any meat that might drip juices or any produce that might come into contact with eggshells. To guard against breakage and odor absorption and to help prevent the loss of carbon dioxide and moisture which lowers egg quality, store raw shell eggs in their cartons. Place egg cartons on a middle or lower shelf where the temperature will fluctuate less than on the door. For longer storage, beat whole eggs just until blended, pour into freezer containers, seal the containers tightly, label with the number of eggs and the date and freeze for up to 1 year. Substitute 3 tablespoons thawed whole egg for 1 large fresh egg. Avoid freezing hard-cooked whole eggs or whites as freezing causes them to become tough and watery. Check occasionally with a thermometer to be sure your refrigerator temperature is 4° C or below and that your freezer temperature is -18° C or below. To maintain safe temperatures, allow cool air to circulate, rather than packing your refrigerator.

Beware of cross-contamination. The egg may not be contaminated when you buy it, but it can become contaminated from other sources, such as hands, pets, other foods and kitchen equipment. Always wash hands with hot, soapy water then dry them with clean (preferably disposable towels) *before* and *after* food preparation, as well as when you're handling raw animal products, such as raw eggs. Always wash surfaces and cooking equipment, including blenders, in hot, soapy water *before* and *after* food preparation.

Bacteria can multiply in moist high-protein foods, including desserts and salads. Don't leave perishables out at room temperature for more than 2 hours and on hot days reduce this time to 1 hour. Cover or wrap any egg mixtures or leftover cooked egg dishes before refrigerating. Refrigeration *slows* bacterial growth, so refrigerate eggs and egg-containing foods.

Do not taste foods that contain raw eggs. It is important to cook eggs thoroughly until the yolks and whites are firm to inactivate any bacteria that are present. Even light cooking will begin to destroy any *Salmonella* that might be present, but proper cooking brings eggs and other foods to a temperature high enough to destroy them all. For eggs, the white will set between 62 and 69° F, the yolk between 69and 70° C, and whole egg between 62 and 70° C. Egg products made of plain whole eggs are pasteurised (heated to destroy bacteria), but not cooked, by bringing them to 60° C and keeping them at that temperature for 3 1/2 minutes. If you bring a food to an internal temperature of 71° C, you will instantly kill almost any bacteria. By diluting eggs with a liquid or sugar (as in custard), you can bring an egg mixture to 71° C. Use these temperatures as rough guidelines when you prepare eggs (AEB, 2000).

All models of microwave ovens tend to cook foods unevenly, leaving cold spots. To encourage more even cooking, cover the dish, stir the ingredients, if possible, and rotate the dish at least once or twice during the cooking time.

EGG DONENESS GUIDELINES (AEB, 2000).

FOOD	GUIDELINES
Scrambled eggs, omelets and frittatas	Cook until the eggs are thickened and no visible liquid egg remains.
Fried eggs	To cook both sides and increase the temperature the eggs reach, cook slowly and either baste the eggs, cover the pan with a lid or turn the eggs. Cook until the whites are completely set and the yolks begin to thicken but are not hard.
Soft-cooked eggs	Bring eggs and water to a full, rolling boil. Turn off the heat, cover the pan and let the eggs sit in the hot water about 4 to 5 minutes.
Poached eggs	Cook in gently simmering water until the whites are completely set and the yolks begin to thicken but are not hard, about 3 to 5 minutes. Avoid precooking and reheating poached eggs.
Baked goods, hard-cooked eggs	These will easily reach internal temperatures of more than 71° C when they are done. Note, though, that while *Salmonella* are destroyed when hard-cooked eggs are properly prepared, hard-cooked eggs can spoil more quickly than raw eggs. After cooking, cool hard-cooked eggs quickly under running cold water or in ice water. Avoid allowing eggs to stand in stagnant water. Refrigerate hard-cooked eggs in their shells promptly after cooling and use them with 1 week.
French toast, Monte Cristo sandwiches, crab or other fish cakes, quiches, stratas, baked custards, most casseroles	Cook or bake until a thermometer inserted at the center shows 71° C or a knife inserted near the center comes out clean. You may find it difficult to tell if a knife shows uncooked egg or melted cheese in some casseroles and other combination dishes that are thick or heavy and contain cheese – lasagne, for example. To be sure these dishes are done, check to see that a thermometer at the center of the dish shows 71° C. Also use a thermometer to help guard against uneven cooking due to hot spots and inadequate cooking due to varying oven temperatures.
Soft (stirred) custards, including cream pie, eggnog and ice cream bases	Cook until thick enough to coat a metal spoon with a thin film and a thermometer shows 71° C or higher. After cooking, cool quickly by setting the pan in ice or cold water and stirring for a few minutes. Cover and refrigerate to chill thoroughly, at least 1 hour.
Soft (pie) meringue	Bake a 3-egg white meringue spread on a hot, fully cooked pie filling in a preheated 177° C oven until the meringue reaches 71° C, about 15 minutes. For meringues using more whites, bake at 163° C (or a lower temperature) until a thermometer registers 71° C, about 25 to 30 minutes (or more). The more egg whites, the lower the temperature and longer the time you need to cook the meringue through without excessive browning. Refrigerate meringue-topped pies until serving. Return leftovers to the refrigerator.

10. Other Country requirements

Country Standard	Requirements
Australia New Zealand Food Standards Code: Standard 2.2.2 Egg and Egg Products NB: This was adopted by State Health Ministers (incl. NZ's) on 24 November 2000. It will run in parallel with the NZ Food Regulations and the current Australian Food Standards Code until November 2002 at which time the latter two pieces of legislation will lapse.	Purpose: This Standard provides definitions for egg and egg products. Processing requirements for egg products and requirements relating to the sale of cracked eggs are included in this Standard and Standard 1.6.2. 1 Interpretation: In this Code - **egg** means the reproductive body in shells obtained from any avian species, the shell being free from visible cracks, faecal matter, soil or other foreign matter. **egg products** means the content of egg, as part or whole, in liquid, frozen or dried form. **visible cracks** includes cracks visible by candling. 2 Processing of egg products (1) Subject to subclause (2), egg products must be pasteurised or undergo an equivalent treatment so that the egg product meets the microbiological criteria specified in Standard 1.6.1. (2) Subclause (1) does not apply to the non-retail sale of egg products used in a food which is pasteurised or undergoes an equivalent treatment so that the egg product used in the food meets the microbiological criteria specified in Standard 1.6.1. 3 Sale of cracked eggs (1) Cracked eggs must not be made available for retail sale or for catering purposes. (2) Cracked eggs sold for non-retail must be pasteurised or have undergone an equivalent treatment so that the egg product meets the microbiological criteria specified in Standard 1.6.1
Australia New Zealand Food Standards Code (ANZFSC): Standard 1.2.3	Unpasteurised egg and egg products are to be labelled with an advisory statement that the product is unpasteurised.
ANZFSC: Standard 1.6.1	Microbiological Limits for Food
EC Council Regulation (EEC) No. 1907/90 Certain Marketing Standards for Eggs and Commission Regulation (EEC) No. 1274/91 and Council decision 94/371 and (EEC) No 12771/75.	Eggs have to be shipped to the licensed packing station at least every third working day, or once a week where the intervening storage temperature does not exceed 18°C (ICMSF, 1998). Also covers labelling of eggs and where eggs of certain grades may be sent.
EC Council Regulation (EC) No 1804/1999.	Covers requirements for organic production of agricultural products.
EC Council Directive 96/23/EC, 29 April 1996,	Certain substances and residues in live animals and animal products are to be monitored. Chapter 2 specifies the

Country Standard	Requirements
Chapter 2 Eggs	sampling to be done at the farm or packing centre. The sample size is at least 12 eggs. The sample rate is at least 1 per 1,000 tonnes of the annual production of consumption eggs, with a minimum of 200 samples per member state. The substances to be checked are listed in annex II as: A6 = Compounds included in Annex IV to Council Regulation (EEC) No 2377/90 of 26 June 1990, (pharmacologically active substances for which no mrls can be fixed and 'Aristolochia spp. and preparations thereof`) (EEC Council, 1990a). B1 = Antibacterial substances including sulphonomides, quinolones, 2b = Anticoccidials, including nitroimidazoles, 3a = Organochlorine compounds inclunding PCBs.
Council Directive 1999/74/EC	Covers the minimum standards for the protection of laying hens.
The Ungraded Eggs (Hygiene Regulations) 1990. UK 1990 No. 1323.	Prevents the sale of eggs containing cracks visible without candling to the naked eye.
USFDA Federal Register: December 5, 2000 (Volume 65, Number 234)[Page 76091-76114]--21 CFR Parts 16, 101 and 115 Food Labeling, Safe Handling Statements, Labeling of Shell Eggs; Refrigeration of Shell Eggs Held for Retail Distribution; Final Rule	The refrigeration requirement will be effective in 6 months, while the safe handling requirement will be effective in 9 months. The regulation requires shell egg cartons to bear safe handling instructions because of eggs' association with Salmonella Enteritidis (SE), a bacterium responsible for foodborne illness. The required statement is as follows: **SAFE HANDLING INSTRUCTIONS:** To prevent illness from bacteria: keep eggs refrigerated, cook eggs until yolks are firm, and cook foods containing eggs thoroughly. The rule requires that eggs be placed promptly under refrigeration at 45°F (7.2°C) or lower upon delivery at retail establishments (supermarkets, restaurants, delis, caterers, vending operations, hospitals, nursing homes and schools). This rule is one part of the larger Egg Safety Action Plan, a farm-to-table approach for ensuring the safety of our nation's egg supply, which was announced by the President on December 11, 1999. The Plan, seeks to reduce by 50 percent the number of *SE* illnesses attributed to contaminated eggs by 2005 and eliminate egg-associated *SE* illnesses by 2010.
US FDA	*Salmonella* Enteritidis positive eggs have to be pasteurised or diverted from market. (Brasher, 2000)

11. Codes of Practice / Control Systems:

Issuer	**Contents**	**Reference**
Codex Alimentarius	Covers eggs in shell and products consisting wholly or mainly of one or more constituents of egg, intended for human consumption. Sections include: • Raw material requirements; • Plant, Facilities and Operating Requirements; • End Product Specifications • Annexes of test methodologies.	Codex Alimentarius (1994). Code of Hygienic Practice for Egg Products CAC/RCP 15-1976, amended 1978, 1985. Volume 11, 1994.
Australian Egg Industry Association	General Food Safety Hazards Personnel Hygiene Requirements Poultry and Packing Buildings The Flock Egg Collection Process Appendices covering food safety program, sanitisers, egg quality, egg standards, egg washing and process temperatures, guidelines for retailers, wholesalers, caterers and food service organisations.	AEIA (Australian Egg Industry Association) (2001). Code of Practice For Shell Egg Production, Grading, Packing and Distribution. 13 February, 2001.
USA	The PEQAP (Pennsylvania Egg Quality Assurance Program) has been developed to promote egg quality and food safety. It contains rules for: egg testing, rodent control, monitoring and testing of chicks, pullets and layers, manure sampling and culturing, farm biosecurity, processing and packaging, carton coding, record-keeping, refrigeration (7.2°C) and disinfection between flocks.	PennAg Industries Association. (1999). Pennsylvania takes lead in egg safety, quality. Press Release. 12/11/99.
USA	The following strategies were identified to eliminate human illnesses due to *Salmonella* Enteritidis in eggs: • Chicks from SE-free breeders • SE testing – environmental, eggs. • Diversion of positives to pasteurisation • Biosecurity • Rodent/Pest Control • Cleaning and disinfection • Prerequisite programmes • HACCP system with a “kill step” • Refrigeration during transport and storage • Food Code Provisions • Monitoring of human infections • Research • Education The goal is to reduce foodborne illnesses associated with *Salmonella* Enteritidis in eggs by 50% by 2005.	President’s Council on Food Safety (1999). Egg Safety From Production to Consumption: An Action Plan to eliminate *Salmonella* Enteritids Illnesses Due to Eggs. December 10, 1999. http://www.foodsafety.gov/~fsg/

Issuer	Contents	Reference
USA	The American Egg Board and United Egg producers is minimising the risk of egg-related *Salmonella* by a voluntary Pro-active Quality Control Campaign that requires control of 5 critical areas: • Poultry house cleaning and disinfecting • Rodent and pest elimination • Proper egg washing • Biosecurity and • Refrigeration.	FSNet (1999): Egg Industry Food Safety Programs. June 30 Press Release. http://www.foodsafety.org/ht/ht430.htm
USA	Includes: • Goals and objectives • Strategy I: SE testing-egg diversion system on farm. • Strategy II: Lethal treatment, or “kill step” at packer/processor. • Detailed Action Plans. • Performance Measures.	USFDA, 1999c. President’s Council on Food Safety. Egg Safety From Production to Consumption. An Action Plan to Eliminate *Salmonella* Enteritidis Illnesses Due to Eggs, 10/12/1999.
Canada	HACCP based programme covering on farm aspects of egg production: • Refrigerated storage (egg coolers to be between 7-13°C). • Facility hygiene • Pest Control • Sorting and Packing • Premises • Sanitary Facilities • Receiving and Storage • General Equipment • Personnel • Records	Canadian Egg Marketing Agency. (1997). Start Clean Stay Clean On-Farm Food Safety Program for Canadian Shell Egg Producers.
Canada	Covers: • Product description • Product ingredients and incoming materials • Process Flow diagram • Plant schematic • Biological, chemical and physical hazards • CCP determination • Controls • Hazards not controlled by the operator • HACCP plan	Canadian Food Inspection Agency (1998). HACCP Generic Model – Shell Eggs. October 1998.

Issuer	**Contents**	**Reference**
Holland	Covers: • Risk analysis: physical, chemical and microbiological • *Salmonella* prevention • Hygiene requirements for the preparation of eggs for consumption • Cleaning and sanitation • Personal hygiene and health requirements • Vermin control • Training • Use of the hygiene code	Dutch Code Of Practice
UK	Covers: • Epidemiology of Human Salmonellosis. • Epidemiology of *Salmonella* in poultry flocks. • Contamination of eggs. • Egg production, distribution and processing. • Use and handling of eggs. • Conclusions and Recommendations.	MAFF, 1993. Advisory Committee on the Microbiological Safety of Food. Report on *Salmonella* in Eggs.
UK	Recommendations include: • Advice to consumers. • Handling and storage of eggs. • Use of pasteurised egg. • Training of food handlers. • Improvements in the monitoring/reporting of Putbreaks of foodborne illness. • Government measures for the control of *Salmonella* in poultry. • Research and surveillance. • Surveillance studies.	MAFF, 1993a. Advisory Committee on the Microbiological Safety of Food. *Salmonella* in Eggs: Recommendations and Government's Response.
UK	Covers: • Production site • Poultry house • Egg collection • Egg storage on the farm • Eggs in transit • Egg grading, packing and labelling • Eggs at wholesalers • Eggs at caterers • Eggs at retailers	MAFF, 1996. Code of Practice. The Handling and Storage of Eggs From Farm to Retail Sale

Issuer	Contents	Reference
UK	Optional "Lion Quality" Code of Practice for Lion Eggs. Control measures include: • Vaccination of all hens against *Salmonella* Enteritidis, • Passport for traceability of hens and eggs, • Registration of all Licensees and listing of associated hatcheries, rearing and laying farms, • Independent auditing of egg farms and packing centres • Feed produced to the UKASTA Feed Assurance Scheme standard, • Modern packing centre technology • Date coding of eggs, • New hygiene controls on egg farms and packing centres including temperature control, • Animal welfare provisions, and • Environmental policies.	British Egg Industry Council. (1998). Egg men crack *Salmonella* problem. http://www.britegg.co.uk/news/news1.htm British Egg Industry Council. (1999). Lion Quality Code of Practice for Lion Eggs, 3rd Version: November 1999.

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13. Summary of Hazards and Other Risk Factors Reasonably Likely to Occur in Shell Eggs

All of the previous information has been summarised into tables that also relate the hazards and other risk factors to their cause or source and possible controls. These tables show the linkage between the hazards and controls in the later sections in this Code of Practice.

The egg producer should consider all of the listed hazards and other risk factors to see whether they need to be included in their RMP. They should also decide whether they have any additional hazards or risk factors that are specific to their own operation.

How to use the Summary Tables on Next Pages

1st column: Each hazard or other risk factor has been given an identification code in this column The letter at the start of the code refers to:
B = Biological hazard,
C = Chemical hazard,
P = Physical hazard,
W = Wholesomeness issue and
L = Labelling issue.
The numbers are issued sequentially.
These codes have been given to help trace the hazards and other risk factors and the controls documented later in the COP.

2nd column: The hazards and other risk factors that were identified in the Technical Annex in Appendix C as reasonably likely to occur have been listed in this column.

3rd column: The cause or source of the hazards and other risk factors have been listed in this column.

4th column: Possible controls are listed in this column. Not all of these controls will be used by every egg producer.

5th column: This column cross references to the later parts of the COP that elaborate on the controls for the hazard or risk factor.

The summary tables below summarise all of the hazards and risk factors identified in the technical annex.

13.1 Summary Of Biological Hazards Reasonably Likely To Occur In Whole Shell Eggs

ID	Examples reasonably likely to occur	Cause/source	Possible controls	For analysis Refer to	
B1	Salmonella species	From hens that are infected or are carriers.	Sourcing layer hens from parent flocks and hatcheries that have been tested and are “not detected” for Salmonella. Use feed that has been tested and is “not detected” for Salmonella. Treatment of hen’s drinking water. Vaccination. Competitive exclusion.	3.7	Farm inputs: bird, feed, water and medication.
			No forced moulting.	3.9	Step 3
			Keeping free range hens away from uncontrolled water sources.	3.8	Other farm sources
		From external contamination of the shell. This is made worse if shell is not intact or damaged, e.g. by vigorous dry cleaning, or through incorrect washing of eggs.	Cleaning and sanitation of shed, cages and conveyor belt.	3.9	Step 1
			Replacement of nest box material.	3.9	Step 3
			Manure removal. Pest control. Personal hygiene. Keeping free range hens out of wet, muddy areas.	3.8	Other farm sources
			Collection of eggs ASAP after laying. Rejection of very dirty eggs. No dry cleaning of eggs. Separation of cracked/damaged eggs.	3.9	Steps 4, 6 & 8
			Correct egg washing procedures.	3.9	Step 7

ID	Examples reasonably likely to occur	Cause/source	Possible controls	For analysis Refer to	
B2	Other enteric bacteria	From hens.	Sorting of eggs so that only clean eggs go for human consumption.	3.9	Steps 4, 5, 6, 7 & 8
		From external contamination of the shell. This is made worse if shell is not intact or damaged, e.g. by vigorous dry cleaning, or through incorrect washing of eggs.	As for salmonella.	3.8 3.9	See above
B3	*Staphylococcus / Streptococcus spp*	Infected food handlers.	Personal hygiene.	3.8 4.8	Other packhouse sources
B4	*Listeria monocytogenes*	From packhouse environment, contaminated equipment and condensation.	Cleaning and sanitation of premises and equipment.	4.8	Other packhouse sources

13.2 Summary Of Chemical Hazards Reasonably Likely To Occur In Whole Shell Eggs[8]

C1	Residues from animal remedies e.g. antibiotics	Incorrect use of animal remedies	Use only approved chemicals for medication. Abide by witholding periods.	3.7	Farm inputs, medication
C2	Residues from chemicals used in shed cleaning, sanitation and fumigation	Incorrect use of chemicals could leave residues on equipment used for feeding and watering hens.	Use only approved chemicals in shed.	3.8	Other farm sources, chemicals
C3	Residues from chemicals used in egg washing	Incorrect use of chemicals.	Use only approved chemicals for washing.	4.7	Packhouse inputs
C4	Residues from chemicals used in egg oiling	Non-food grade oils used to seal washed eggs.	Use only approved chemicals for oiling.	4.7	Packhouse inputs

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[8] This is a summary of the information presented in the technical annex which can be found in Appendix C.

13.3 Summary Of Physical Hazards Reasonably Likely To Occur In Whole Shell Eggs[9]

ID	Examples reasonably likely to occur	Cause/source	Possible controls	For analysis Refer to	
P	N/a – no physical hazards likely to occur because of the protective nature of the shell.				

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[9] This is a summary of the information presented in the technical annex which can be found in Appendix C.

13.4 Summary Of Risks To Wholesomeness Reasonably Likely To Occur In Whole Shell Eggs

ID	Examples reasonably likely to occur	Cause/source	Possible controls	For details Refer to	
W1	Blood or meat spots	Caused by a rupture of one or more small blood vessels in yolk at ovulation.	Keep flock age as low as economically possible. Feed to have vitamins A & K. Do not allow feed lines to become wet or mouldy.	3.7	Farm inputs: birds, feed
W2	Watery whites	Egg is aging or hen is infected with infectious bronchitis virus or other viral diseases.	Collect all eggs ASAP after laying.	3.9	Step 4
			If birds are sick contact an avian vet for advice on vaccination.	3.7	Farm inputs, medication
W3	Roundworms in eggs	Internal parasite of the hen can migrate to oviduct and be enclosed in egg.	Medication.	3.7	Farm inputs, medication
			Keep birds off fouled or damp ground or litter.	3.8	Other farm sources
			Disinfection of poultry house.	3.9	Step 1
W4	Off odours and flavours	Strongly flavoured feed ingredients, e.g. fishmeal.	Change feed composition to reduce suspect ingredient.	3.7	Farm inputs, feed
W5	Rotten eggs	Spoilage due to *Pseudomonas* bacteria. Storage at high temperatures.	Reject extremely dirty eggs. Wash other dirty eggs using correct procedures. Maximum storage temperature = 15 °C.	3.9 4.9	Steps 4, 5, 6,7, 8, 11
W6	Pink or iridescent egg whites.	Spoilage due to *Pseudomonas* bacteria Storage at high temperatures.	Reject extremely dirty eggs. Wash other dirty eggs using correct procedures. Maximum storage temperature = 15 °C.	3.9 4.9	Steps 4, 5, 6,7, 8, 11
W7	Eggs that are older than their use by date.	Delayed egg collection, packing or selling. Incorrect date coding.	Collect all eggs ASAP after laying. Check that eggs are not trapped in cages. These may eventually roll out and be collected when they are stale.	3.9	Step 4

ID	Examples reasonably likely to occur	Cause/source	Possible controls	For details Refer to	
W8	Soft shells.	Inadequate feed, water.	Improve feed composition.	3.8	Farm inputs, feed
W9	Mouldy eggs	Delayed egg collection.	Collect all eggs ASAP after laying.	3.9	Step 4
		Poor storage and handling. When temperature fluctuations result in condensation on eggs.	Maximum storage temperature = 15 °C. Maximum humidity = 80%.	3.9	Steps 5, 11
			Clean and disinfect storage rooms regularly.	3.8 4.8	Other sources

13.5 Summary of Risks Of False Or Misleading Labelling Reasonably Likely To Occur In Whole Shell Eggs

ID	Examples reasonably likely to occur	Cause/source	Possible controls	For details Refer to	
L1	Incorrect claims re caged, barn, free range or organic eggs.	Birds not qualifying for claim.	Check birds meet criteria.	3.7	Farm inputs, birds
		Incorrect label design. Use of incorrect label or pack. Use of recycled packaging with wrong label.	Checks of label proofs for new labels. Check of labels and packages at start of each day and for each change of shed. Clear labelling of all egg containers.	3.9 4.9	Steps 4-10
		Mix up of eggs.	Collect and process different egg types in separate batches and store in different areas.	3.9 4.9	Steps 4-10
L2	Incorrect date marking	Delayed collection. Date not changed.	Check date at start of each day. Do not reuse packaging.	3.9 4.9	Steps 4, 10