AUSTRALIAN EGG CORPORATION LIMITED

# An Egg:*Salmonella* Quantitative Risk Assessment Model

## for the Australian Egg Industry

## Appendices

March 2006

AECL Project SAR-42A

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# Appendix 1
# Survey of Egg-Related Salmonellosis Outbreaks in Australia

**Use a separate form for each incident**
**Please complete all questions, if an answer is not known write "unknown"**

1. Outbreak ID (provide location, date, & descriptive title)

   ..............................................................

2. What was the source of the eggs believed to have been associated with the outbreak? Please tick (indicate if eggs from more than one source are present)

   - A commercial farm/retail system ☐
   - A non-commercial source (eg home backyard) ☐
   - Purchased/obtained direct from a commercial egg layer farm ☐

3. A) Were cracked eggs used in the preparation of the suspect food item? (ie had the eggs visible cracks in the surface

   YES / NO / Unknown

   B) or were they sold as "seconds")

   YES / NO / Unknown

4. With regard to the suspect food item:

   - What was the suspect food item? (eg mayonnaise)

     ......................................................

     ......................................................

   - Indicate how was this confirmed:

     Laboratory evidence ☐

     Epidemiological association ☐

     ......................................................

5. Where was the suspect food item prepared (please indicate)

   - Commercial food premises (eg restaurant, bakery, café) ☐
   - In the home ☐
   - In an institutional setting (eg aged care facility) ☐
   - Other – please describe (eg camping, function caterer etc) ☐

     ........................................

6. How many eggs were used to prepare the suspect food item? (provide product batch volume if known)

[ ]

............................................................

............................................................

7. Were the suspect food items or remaining eggs tested?

YES / NO

- If YES which serovar(s) were found?

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- If positive, are cell counts (MPNs) available (give details)?

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8. Was the suspect food item cooked or uncooked? (eg baked or unbaked cheesecake)

COOKED / UNCOOKED

9. Was there any traceback investigation to the source of the eggs? (eg drag swabs taken at the layer farm)

YES / NO

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............................................................

- Are any test results available for drag swabs? (ie serovars found)
  YES / NO

If YES which serovars were found

.....................................................................

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- Were any eggs tested from the layer farm?
  YES / NO

  If tested, how many eggs were tested?

  Were the eggs individually tested or pooled for testing?

  ...................................................................

10. Were the eggs part of a school project? (eg hatching chickens in the classroom)

    YES / NO

.....................................................................

.....................................................................

.....................................................................

11. Was there any potential cross contamination? (eg dripping meat juices from thawing meats in a cool room onto salads, or re-use of piping bags with other ingredients)

    YES / NO

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.....................................................................

12. In the suspect food item were:
    - Whole eggs used?
      YES / NO
    - Egg whites?
      YES / NO

- Egg yolks?
  YES /NO
- Commercial egg pulp?
  YES / NO

13. Of the cases:

    - How many people consumed the suspect food item?
    - How many reported symptoms?

- How many were lab confirmed with the same serovar? ☐
- How many hospitalised (give details of recorded cases)? ☐

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  ……………………………………………………………

  ……………………………………………………………

  ……………………………………………………………

  ……………………………………………………………
- Were there any fatalities recorded?

  YES (provide numbers) / NO

14. Please give an indication of the numbers of people taken ill in the following categories
    - Children (0-4 years old) ☐
    - Adults (5-69 years old) ☐
    - Elderly (70+ years old) ☐
    - Vulnerable population groups (eg immunocompromised/institutionalised) ☐

15. Was there any overseas travel prior to illness? (please give destination)

    ……………………………………………………………

    ……………………………………………………………

16. Were there any other contributing causes? (eg temperature abuse during power failure)

    YES /NO

    ……………………………………………………………

    ……………………………………………………………

    ……………………………………………………………

17. Food Handlers
    - Did any food handlers report being ill? (provide number if known)?

      YES / NO ☐

- Did food handlers have symptoms prior to consumers of suspect food items?

  YES / NO

  …………………………………………………………………

  ……………………………………………………………………

  ……………………………………………………………………

- Were any food handlers confirmed by laboratory diagnosis?

  YES / NO

  ………………………………………………………………

  …………………………………………………………………

  …………………………………………………………………

Thankyou for your participation.

Please return to Martyn Kirk – OzFoodNet, or directly to:

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# Appendix 2
# *Salmonella*:Egg and Egg Product Hazard Identification

## 2.1 Information on Food-borne Salmonellosis in Australia

In Australia, the vast majority of notifiable, gastrointestinal illnesses are caused by *Salmonella* (Table 2.1) and *Campylobacter*.

**Table 2.1: Notification of Salmonellosis infections in Australia 1991-2002 (Source: CDNA – NNDSS; http://www.cda.gov.au/surveil/index.htm, 2003)**

| | **Salmonellosis** | |
|---|---|---|
| | **Number of cases** | **Rate/100,000 population** |
| 1991 | 5496 | 31.5 |
| 1992 | 4416 | 25.3 |
| 1993 | 4505 | 25.4 |
| 1994 | 5199 | 29.1 |
| 1995 | 5873 | 32.5 |
| 1996 | 5876 | 31.5 |
| 1997 | 7054 | 38.0 |
| 1998 | 7613 | 40.5 |
| 1999 | 7147 | 37.8 |
| 2000 | 6229 | 32.6 |
| 2001 | 6868 | 35.2 |
| 2002 | 7787 | 40.0 |

### Food Recalls

Food recalls represent a front-line data source for hazard identification that indicate the incidence of a broad range of contamination. According to the FSANZ database during the 2001/2002 financial year, there were no recalls (Table 2.2) in which eggs or egg-based products were confirmed as the cause.

**Table 2.2: Food Recalls for all foods in 2001-2002 Financial Year (Source: FSANZ 2002)**

| **Number** | **Reason** |
|---|---|
| 28 | Microbiological e.g. *L. monocytogenes*, *Salmonella*, *E. coli* etc |
| 13 | Chemical contamination (chloropropanols, cleaning solution) |
| 13 | Inclusion of foreign matter, e.g. glass, metal etc |
| 7 | Labelling errors i.e. product includes ingredients not listed on the label and could cause an allergic reaction |
| 4 | Processing malfunctions |
| 4 | Biotoxin contamination |
| 2 | Product does not meet FSC e.g. excessive colour or lead levels |
| 1 | Choking hazard |
| 1 | Prohibited botanical |
| **Total 73** | |

Of the recalls listed in Table 2.2, 33 involved imported products (45%), including 12 soy sauce products recalled as a result of excessive levels of chloropropanols. Physical hazards were responsible for 18% of the listed food recalls. Recalls of poultry products are listed in Table 2.3.

**Table 2.3: Poultry-related Recalls Report for 2001-2002 Financial Year (FSANZ 2002)**

| Product | Reason for Recall |
|---|---|
| Chicken curry – vacuum packed | Insufficient cooking |
| Chicken and vegetable pie (soy flour contaminated source) | *Salmonella* contamination |
| Chicken nuggets (frozen) | Contamination with plastic |
| Chicken pepperoni – vacuum packed | Insufficient cooking |

## 2.2 Laboratory and Industry Monitoring Results for Layer Flocks, Stockfeeds, Egg and Egg Products in Australia

### Layer flock serovars

The profile of *Salmonella* serovars isolated from the routine monitoring of the environment of flocks for SE freedom in NSW is shown in Table 2.4 (these isolates are not included in the NEPSS data for the same period). In this scheme 3 colony picks are evaluated for each positive plate; if initial identification indicates multiple strains all 3 are sent to the IMVS for serotyping. Multiple serovars have been isolated concurrently from Australian layer flock environments (Cox 1993), though the low incidence of *Salmonella* recorded in NSW flocks suggests this to be unlikely in most instances. The sensitivity of environmental sampling is also an important consideration in this context (reviewed by Wilks *et al* (2000). While studies in the US on SE positive farms indicate a low probability of detection particularly when contamination levels are low, the sensitivity is improved with repeat sampling. This is the approach adopted in NSW, and it has been recommended to AECL as the preferred method for the mooted national SE monitoring program.

Data over 3 years from NSW found only 3.1% (2.4%-3.9%, 95% CI) of 2252 monthly shed drag swab tests were positive (Table 2.4), with only 8.7% (3.3%-18.0%, 95% CI) of these 69 shed test positives with the same serovars at the following monthly test.

A low isolation rate in Queensland flocks was also reported (Cox 1993; Cox *et al* 2002), however, these data do not represent a systematic survey of industry, but is the best available published data. *Salmonella* serovars were isolated in feed and the animal protein meals in use, and it was concluded that these serovar incursions were transient rather than representative of longer-term colonisation of the layer flock. This is supported by the data from routine flock environment monitoring in NSW.

### Shell eggs and processed egg serovars

A summary of laboratory testing of shell eggs and processed eggs at the IMVS in SA is provided in Table 2.5, while the positive isolates reported to NEPSS from raw eggs and egg products are in Table 2.6. Data from NEPSS (2000-2003) represents isolates from raw eggs, processed egg product, foods containing eggs and egg processing equipment submitted for serotyping at MDU. The majority of these isolates originate from Victoria. The bulk of isolates are from a range of raw egg products, with *S*. Singapore, *S*. Cerro and *S*. Typhimurium being the most commonly isolated serovars (Table 2.6). Isolates from foods investigated in outbreaks are included in these data. While NEPSS data are not based on any statistical sampling basis and tested pulp may not always be limited to eggs from commercial layers, the qualitative impact of *Salmonella* is considered sufficiently important to identify this organism as the target pathogen of concern in egg products.

In addition, as part of this project, five egg processors across Australia were surveyed for the frequency of testing for the presence of *Salmonella* in liquid egg products. The processors reported sampling between two and 10 times per week, depending on the quantity of liquid egg pasteurised.

The main serovars isolated in egg pulp surveys in Queensland in the 1990s were *S*. Singapore, *S*. Mbandaka, *S*. Cerro and *S*. Infantis (Cox *et al* 2002). National data covering the period 2000 to 2003 (Table 2.6) is consistent with this earlier Queensland data. Contamination of raw whole egg sampled over 14 months at single egg processing facility in Queensland was very high (95% of 110 samples), presumably due to pooling across farms. In contrast 23% of 856 farm egg pulp samples were positive indicating contaminated pulp from a single farm may contaminate the rest of the pulp. The isolation of *S*. Infantis, particularly from egg yolk product, is of concern due to its public health significance in other countries (Cox *et al* 2002). However, the frequency of isolation was found to be low relative to other serovars, and this appears to be the situation in recent NEPSS data (Table 2.6). Concerns raised in relation *S*. Infantis have not materialised to date as outbreaks attributed to *S*. Infantis, or to egg pulp: *S*. Infantis combinations have not been reported in Australia (Table 2.7).

## Egg processing equipment serovars

In the period 2000-2002, 33 isolates from egg processing equipment reported to NEPSS (J Powling pers.comm. 2003) were recorded (*S*. Agona 9 isolates, Broughton 3, Infantis 16, Ohio 1, Singapore 3, Virchow PT34 1). Four of these serovars were also isolated from pasteurised egg product highlighting the potential for post-processing recontamination (Table 2.6).

## Stockfeed serovars

Potential exists for introduction of *Salmonella* serovars into layer flocks via contaminated stockfeeds. A review of 5 years of testing of animal feedstuffs and stockfeeds by NEPSS (1998-2002) reveals 2,683 isolates of *Salmonella*. Of these isolates only 0.8% was *S*. Typhimurium, all being isolated in 2001 predominantly from meat and bone meal. This low isolation rate of *S*. Typhimurium is consistent with the NSW (Table 2.4) and Qld flock environment data (Cox 1993; Cox *et al* 2002).

The most commonly isolated serovars from animal feedstuffs in recent years (NEPSS 2000-2002) include *S.* Orion var 15+, *S.* Agona, *S.* Anatum and *S*.subsp I ser 4,12:d:-. Over this period these serovars were also isolated from pelleted stockfeeds. The potential for flock and egg contamination from serovars entering the flock via contaminated feed is inferred from the isolation of the same serovars from layer flocks environment (Table 2.4) and raw egg products (Table 2.6) recorded over the same 3 year period.

In comparison, *S*. Typhimurium is only rarely isolated in relation to other serovars from layer flock environments (Table 2.4; Cox *et al* 2002), but is relatively common in comparison to other serovars in raw egg pulp (Table 2.6) and in outbreaks in which eggs are included in the implicated food (Table 2.7).

Cox (1993) also reported a low incidence of flock environment contamination in Queensland, with serovars reflecting those found in feeds and animal protein meals used at the time. Overall, common serovars in found pulp reflected those found commonly in the layer environment during the study period (Cox *et al* 2002).

**Table 2.4: *Salmonella* serovars isolated from layer flock environments in New South Wales 2000-2003**

| ***Salmonella* Serovar** | **Isolates from NSW SE monitoring scheme 2000-2002[1]** | | | |
|---|---|---|---|---|
| | **2000 (48 farms, 822 shed tests)** | **2001 (44 farms, 804 shed tests)** | **2002 (42 farms, 626 shed tests)** | **NSW Total (48 farms, 2252 shed tests)** |
| Agona[2, 3] | 7 | 1 | 2 | 10 |
| Bovismorbificans | 1 | | | 1 |
| Give | | | | |
| Havana[3] | | | | |
| Infantis[2, 3] | 4 | 1 | 1 | 6 |
| Kiambu[2] | | | | |
| Kottbus | | 1 | | 1 |
| Livingston | | 1 | 3 | 4 |
| Mbandaka[2, 3] | | | | |
| Muenchen | | | | |
| Ohio[2, 3] | | | 1 | 1 |
| Orion[2, 3] | 2 | 1 | 1 | 4 |
| Senftenberg [2, 3] | 4 | 3 | 1 | 8 |
| Singapore[2, 3] | | | 1 | 1 |
| Sofia | 7 | | 8 | 15 |
| Tennessee[2] | 1 | | 2 | 3 |
| Typhimurium | | 2 | | 2 |
| untypable | | | | |
| subsp. 1 ser 3,19:-:- | | 3 | | 3 |
| subsp 1 ser 4,12:d:-[3] | | | 10 | 10 |

[1] Data from IMVS serotyping

[2] Relatively commonly isolated from stock feeds compared to other serovars;, meat meal and meat and bone meal predominantly (NEPSS 2000-2002)

[3] Isolated from layer flocks in Queensland (Cox 1993, Cox *et al* 2002)

**Table 2.5: IMVS Food Lab *Salmonella* testing of shell eggs and processed eggs (1998-2003)**

| **Product** | **Year(s)** | **Number of samples** | **Number of samples in which *Salmonella* was detected** | **Reference** |
|---|---|---|---|---|
| Eggs & processed eggs* | Jan 1998 to Dec 2001 | 339 | 0 | Murray (2002) |
| Processed egg* | Jan to Dec 2002 | 41 | 0 | Murray (2003) |
| Egg (AQIS) | Jan to Dec 2002 | 27 | 0 | Murray (2003) |
| Raw egg pulp** | Jan-March 2003 | 6 | 2*** | Murray (2003) |

* pasteurised egg product

** commercial unpasteurised pulp, not outbreak related

*** *S*. Bovismorbificans PT24: also reported in Table 2.6

**Table 2.6:** ***Salmonella*** **isolates and phage types from eggs, processed egg and egg products and notified to NEPSS from laboratories across Australia over the period 2000-2003 (Source NEPSS, Non-human data)**

| ***Salmonella* Serovar** | **Egg and Egg Product Type** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Raw Egg Pulp** | **Raw Egg White /White Mix** | **Raw Egg Yolk** | **Egg Powder / Whole Egg Powder** | **Boiled Egg** | **Scrambled Egg** | **Pasteurised Egg Pulp** | **Pasteurised (Salted) Egg Yolk** | **Egg Unspecified** | **Egg Product (mainly Mayonnaise)** |
| Agona* | 5 | | | | | | 1 | | | |
| Anatum* | 4 | | | | | | | | | |
| Bovismorbificans PT24 | 2** | | | | | | | | | |
| Cerro* | 1 | 11 | | | | | 2 | | | |
| Infantis* | 2 | | | | | | | 1 | | |
| Johannesburg | 1 | | | | | | | | | |
| Kiambu* | | 1 | | | | | | | | |
| Mbandaka* | 2 | | | | 1 | | | | | |
| Ohio* | 6 | | | | | | 2 | 2 | | |
| Oranienburg | 1 | | | | | | | | | |
| Orion* | 2 | | | | | | | | | |
| Singapore | 3 | 1 | | 23 | | | | | | |
| Tennessee* | | | | | | 1 | | | | |
| Typhimurium PT8 | | | | | | | | | | 1 |
| Typhimurium PT 9 | 13 | 2 | | | | | | 2 | | 13 |
| Typhimurium PT 102 | | | | 1 | | | | | | |
| Typhimurium PT 126 | | | | | | | | | | 3 |
| Typhimurium PT 135 | 3 | 7 | 3 | | | | 1 | | 3 | 3 |
| Typhimurium PT 170 | | | | 1 | | | | | | |
| Typhimurium RDNC | 1 | | | | | | | | | |
| Typhimurium untype | 9 | | | | | | | 1 | | |
| Virchow PT 34 | 7 | | 1 | 2 | | | | 1 | | |
| Subsp 1 ser 1,3,19:-:- | 1 | | | | | | | | | |
| **Total Isolates** | **63** | **22** | **4** | **27** | **1** | **1** | **6** | **7** | **3** | **20** |

* Relatively commonly isolated from stock feeds compared to other serovars, meat meal and meat and bone meal predominantly (NEPSS 2000-2002)
** Same *S*. Bovismorbificans phage type 24 as reported by IMVS in 2003 (Table 2.5)

## 2.3 Epidemiology of Outbreaks Implicating Foods Containing Eggs in Australia

### Introduction

Summary data from outbreaks are a valuable source of information about causes of food-borne Salmonellosis. These data can help determine populations at risk of infection, foods that are commonly associated with disease, and circumstances leading to outbreaks. These summaries can lead to development of policy to prevent future outbreaks. One limitation of using outbreak data is that the majority of cases of Salmonellosis are not part of recognised outbreaks. It is also more common to detect outbreaks where there are large gatherings of people, or in association with certain types of foods. Outbreak investigations are very difficult to conduct, as they are often recognised well after the original exposure occurred. This means that food samples are often not available for testing and it is difficult to determine the real source of contamination. Despite these limitations, systematic reviews of outbreaks are still useful and in this section outbreaks of Salmonellosis, implicating foods in which eggs were an ingredient, are reviewed. It is important to note that one of the difficulties is that eggs are a common ingredient in a broad range of foods, which leads to their frequent consideration by investigators.

### Source of information

For the purposes of this Hazard Identification, details of investigations of 26 outbreaks, between 1991 and 2002, in which food(s) containing eggs were implicated (Table 2.7) were extracted from original case notes and reports by Communicable Disease Control epidemiologists responsible for food-borne disease investigations in each state, respectively. As a result, these outbreak profiles avoid interpretive errors as far as possible.

OzFoodNet collects summary information on all outbreak investigations in Australia using a generic questionnaire that records the food vehicle, setting of food consumption and preparation, aetiological agent and potential sources of contamination. To supplement this, the project team prepared an additional survey form that included questions specifically related to outbreaks implicating eggs to further characterise relevant information (Appendix 1). Additional factors included egg source type (i.e. non-commercial backyard, commercial), supply of cracked eggs, direct purchase off commercial farm etc. While this type of information was inconsistently recorded in investigations, the questionnaire provides public health officials with a tool to assist in subsequent outbreaks when eggs may be suspected. The outbreaks cited in Table 2.7 represent those where investigations inferred foods containing eggs as the food vehicle most likely to be the source of exposure. The outbreaks examined here are those where OzFoodNet epidemiologists identified that the original investigations suspected eggs as the cause of the outbreak.

The 26 outbreaks are summarised in Table 2.8 by cross-tabulating the criteria listed above with details of other contributing factors. The cross-tabulation approach follows that used by Todd *et al* (1997) and Panisello *et al* (2000) for the identification of hazards and use of contributing factors to define control and critical control points.

### *Salmonella* serovars

While a range of serovars are involved, *S.* Typhimurium account for 73% (19) of the 26 outbreaks (Tables 2.7 and 2.8). Among these 19 outbreaks, 74% (14) were associated with backyard or unspecified layer sources. *S.* Typhimurium was not isolated on 3 commercial farms investigated that were associated with *S.* Typhimurium outbreaks (19, 30, 36) but was recovered on 4 of 6 backyard and unspecified sources investigated (1, 18, 24, 37; Table 8). Two of these latter outbreaks (1 and 24) had relatively uncommon *S.* Typhimurium PT 9 and U307 isolated from non-commercial egg sources when compared to routine flock monitoring (Table 2.4), but *S.* Typhimurium PT 9 is not uncommon in egg product testing by NEPSS (Table 2.6) and IMVS (Murray 2004).

Gaining a better understanding of the disparity between the infrequent isolation of *S*. Typhimurium in systematic flock monitoring programs and commonly in outbreaks in foods containing eggs is central to this hazard identification process. Possible explanations that may account for the disparity are:

- possibly greater potential for *S*. Typhimurium to infect (including lower infective dose) and capacity to cause disease
- higher prevalence of *S.* Typhimurium in internal contents of eggs than other serotypes
- cross-contamination from non-egg food ingredients (Table 2.7 and Table 2.8)
- contamination from humans, a species in which *S.* Typhimurium is a dominant serovar; (isolation positive food handlers reported in outbreaks 17, 25, 30, 31)
- *S*. Typhimurium is possibly better adapted to growth and survival in some food items and egg products compared to the most common strains identified in live birds and the environment
- the transient nature of *Salmonella* serotypes in poultry layer flocks, which are not detected by routine layer environmental surveillance

The current sampling and testing of other food ingredients and processing environments in investigations of food-borne outbreaks is critical. Notably**,** over the past 5 years, *S.* Typhimurium and *S.* Typhimurium PT135 have been the most common serovars isolated from bovine and ovine sources and from chicken meat (Table 2.12).

The data in Table 2.7 indicate the potential for regional environmental reservoirs of *Salmonella*. For example, of the three outbreaks of disease associated with *S.* Heidelberg, all were located in Queensland, a similar finding to that reported in the US (Hennessy *et al* 2004). Similarly the observation that SE phage type 26 seems to be restricted to Queensland (Cox, 1993; Table 2.16) lends further support to this hypothesis.

## Exposed populations

In 42% of the 26 outbreaks listed in Table 2.7 were investigators able to quantify the exposed population. As many of these investigations of *Salmonella* infections were usually community-based it was impossible to determine the true cohort of people exposed. In addition many did not occur in a point-source setting.

Vulnerable populations were involved in 8 of 26 food-borne outbreaks in which eggs were implicated (Table 2.9). The relative proportion of these among all outbreaks may be a result of ease of recognition and/or greater susceptibility of those exposed. Vulnerable populations are defined as those comprising the aged (over 65 years and/or retirees), hospital patients, and children in pre-school child-care centres. In 4 of these outbreaks eggs were obtained from non-commercial (includes backyard) sources; the source of eggs was not reported in 2 outbreaks. In 4 of the outbreaks, raw egg/egg product was used (Outbreaks 2, 7, 9 and 18). Boiled eggs were used in sandwiches in another 3 outbreaks (2 of which were curried egg). In these situations, the potential for post-cooking contamination or use of contaminated spices are pertinent for investigators to consider.

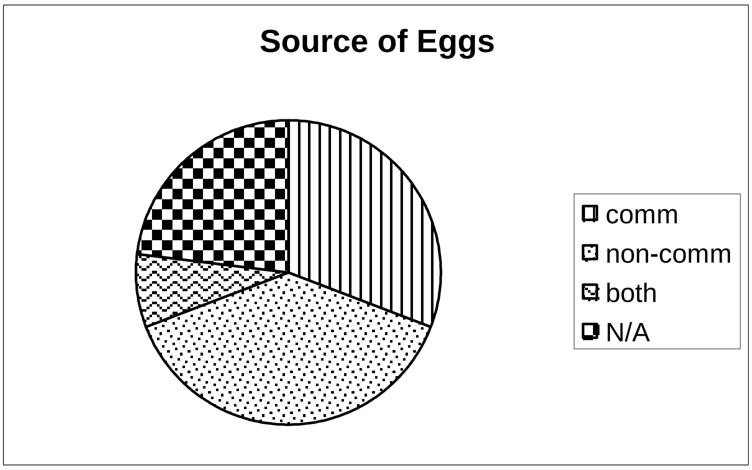
## Source of eggs

The source of eggs implicated in the 26 outbreak investigations is listed in Table 2.8 and Figure 2.1.

In this context, 50% (n=13) of these layer sources were investigated, with the outbreak serovar being isolated on five occasions (i.e. outbreak serovar isolated from the egg source in 38% of outbreaks investigated). These included *S*. Typhimurium (PT 9, 135, 135a, U307) in 4 investigations and *S*. Virchow PT34 in one investigation.

The outbreak serovar was isolated from backyard/non-commercial and unspecified sources on four occasions (of 8 sources investigated for these egg source categories) and once from an implicated commercial farm (of 5 farms investigated).

**Figure 2.1: Source of eggs used in foods implicated in 26 food-borne disease outbreaks**

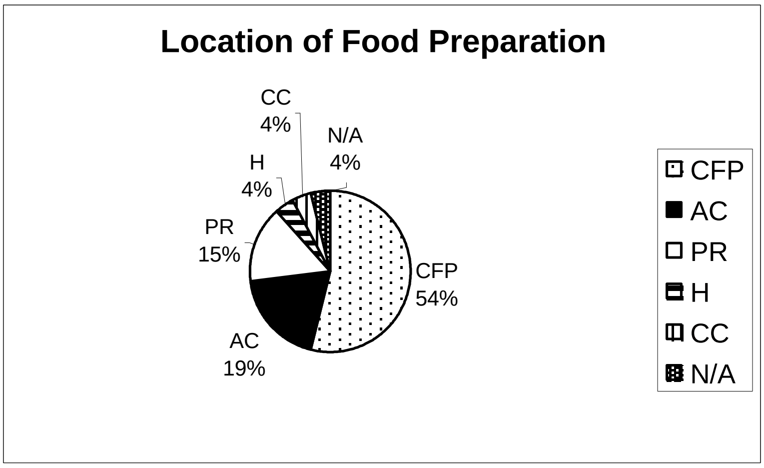



| | | |
|---|---|---|
| comm | Commercial | 8 |
| non-comm | Non-Commercial | 10 |
| both | Both Commercial and Non-Commercial | 2 |
| N/A | Not Available | 6 |

## Location of food preparation

The proportion of the 26 outbreaks of Salmonellosis associated with different types of food premises is reported in Figure 2.2. As might be expected, the potential for exposure of relatively large groups of consumers over short periods is associated with commercial food premises and caterers to institutions. Commercial food premises were implicated in 14 (54%) of outbreaks and a further 5 (19%) with aged care facilities.

**Figure 2.2: Proportions of egg-related outbreaks of Salmonellosis listed by categories of food preparation premises**



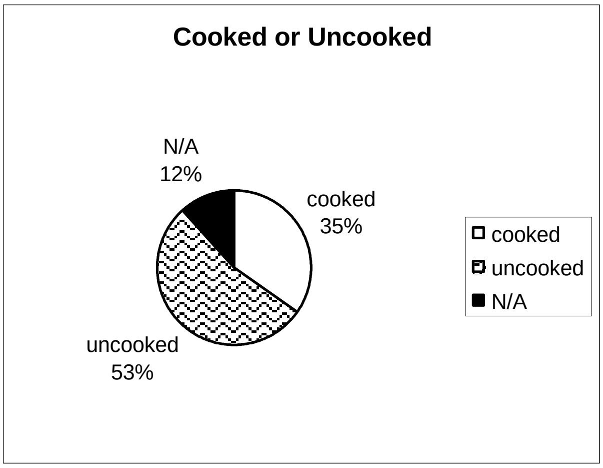

| | | |
|---|---|---|
| CFP | Commercial Food Premises | 14 |
| AC | Aged Care | 5 |
| PR | Private Residence | 4 |
| H | Hospital | 1 |
| CC | Child Care | 1 |
| N/A | Not Available | 1 |

## Cooked and uncooked foods

Information on whether the consumed eggs had been cooked or uncooked was obtained for 23 outbreaks in which eggs were an ingredient in the implicated foods (Tables 2.7 and 2.8). Inclusion of uncooked eggs in milk drinks (often served to vulnerable populations), mayonnaise, and added after cooking with no further kill step were repeated outbreak scenarios. Cooked eggs were used in implicated foods in 9 outbreaks and consumed in an uncooked state in foods in 14 outbreaks (Figure 2.3, Table 2.7). Furthermore, in 4 of 8 outbreaks involving vulnerable populations, the implicated drinks/foods contained uncooked eggs (Table 2.9); 2 being from backyard sources and 2 from unspecified sources.

An examination of outbreaks associated with cooked egg product reveals the serovars isolated are either not, or are uncommonly, isolated on-farm (*S*. Typhimurium PT 135 and 135a, *S*. Heidelberg PT16, *S*. Hadar PT22, *S*. Typhimurium RDNC/AO41), however, *S*. Typhimurium in particular are commonly isolated from egg products (Table 2.6) and poultry and other meats (Table 2.12). The act of cooking eggs or foods containing eggs, may not necessarily be protective in these outbreaks.

**Figure 2.3: Proportion of cooked and uncooked egg-associated foods implicated in outbreaks of Salmonellosis.**




## Use of cracked eggs

In eight outbreaks (Table 2.8) the presence and use of cracked/dirty eggs, was implicated by public health investigations. In four outbreaks (6, 7, 8, 37) eggs were from non-commercial sources, however, in outbreak 23 these were supplied direct from a commercial farm (grading status unknown). The source of eggs in outbreak 4 was not recorded. In only one case (outbreak 37) was the serovar verified on the basis of layer source follow up. While the evidence cited is limited and equivocal the authors conclude the use of cracked eggs represents potential for introduction of *Salmonella* into foods and increased potential for outbreaks as predicted by Todd (1996).

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**Table 2.7: Profiles of 26 investigations where foods containing eggs amongst other ingredients were suspected as being involved in food-borne infections by *Salmonella* spp.**

| Year | State | ID | Vehicle (cooked/ uncooked) | Serovar/Phage Type | Investigation Methodology | No. Ill (Exposed) | No. Hospitalised | No. Fatalities | Age Distribution | Case assessment |
|---|---|---|---|---|---|---|---|---|---|---|
| 1991 | VIC | 23 | Gelati (uncooked) | *S*. Typhimurium PT135 & PT145 | CS/LE | 47 | | 0 | | Egg yolk heated to 80°C, cooled at room temp., whites added post-cooking. Cracked eggs supplied direct from commercial farm. |
| 1996 | NSW | 2 | Egg flip (uncooked) | *S*. Typhimurium PT9 | CS | 13 | | 1 | 13V | Raw egg flip for patients. Source of eggs unknown. |
| 1996 | QLD | 6 | Anglaise Sauce/ Chocolate Parfait (cooked) | *S*. Heidelberg PT16 | CS/LE | (500+) | 56 | 0 | | Parfait served on flights between Qld & Japan. Custard prepared by subcontractor using cracked 'seconds' eggs from a non-commercial farm. Product not refrigerated properly by subcontractor. |
| 1996 | QLD | 36 | Curried egg sandwiches (cooked) | *S*. Typhimurium RDNC/AO41 | CS/LE | 52 | | 1 | V | Hard-boiled eggs stored in modified atmosphere packaging. Spices untested. Eggs from commercial source |
| 1996 | VIC | 24 | Mayonnaise (uncooked) | *S*. Typhimurium U307 | CS | 36 | 12 | 0 | 41.8 (mean) | Mayonnaise, using whole raw egg, supplied by catering wholesaler. Egg source unknown |
| 1998 | NSW | 3 | Curried egg (cooked) | *S*. Typhimurium PT135 | CS/Epi | 11*(8) | | 0 | 11A | Spices (culture neg), added to egg after cooking; suspected as source of post-cooking contamination but usually exotic serovars. Egg source unknown. Retirees. |
| 1998 | VIC | 25 | Unknown | *S*. Virchow PT34 | CS | 12(22) | | | V | Poor food handling, food handler also ill. Food vehicle not determined. Eggs purchased direct from positive commercial farm. |

| Year | State | ID | Vehicle (cooked/ uncooked) | Serovar/Phage Type | Investigation Methodology | No. Ill (Exposed) | No. Hospitalised | No. Fatalities | Age Distribution | Case assessment |
|---|---|---|---|---|---|---|---|---|---|---|
| 1998/ 99 | VIC | 22 | Custard cake/ fresh pasta (uncooked) | *S*. Typhimurium PT9 | CS/Epi | 54 | | 0 | 17 (median) | Food handling errors; custard left unrefrigerated & uncovered to cool. Cross-contam most likely source. Commercial retail eggs, commercial egg pulp & backyard eggs used. |
| 1999 | NSW | 4 | Fish with egg sauce (cooked) | *S*. Typhimurium PT135 | CS | 16 | | 0 | | Cracked eggs used. Egg sauce only lightly heated. Egg source not recorded. |
| 1999 | QLD | 7 | Egg Nog (uncooked) | *S*. Heidelberg PT1 | CS | 7(7) | 0 | 0 | 7V | Nursing home. Cracked, non-commercial, raw eggs used in egg flips. |
| 1999 | QLD | 8 | Tiramisu/ Chocolate mousse (uncooked) | *S*. Typhimurium PT8 | CS/LE | 49 | 2 | 0 | | Uncooked dessert. Non-commercial, raw eggs, probably cracked. Inadequate cleaning and up to 5 hours on display. Also from Parmesan cheese and anchovies. |
| 2000 | ACT | 1 | Mayonnaise or home-made curried egg (uncooked) | *S*. Typhimurium PT9 | CS/LE | | 0 | 0 | 3C/19A | Mayonnaise kept at room temp. Eggs from commercial and (positive) non-commercial farms |
| 2000 | QLD | 13 | Egg & lettuce sandwiches (cooked) | *S*. Mbandaka | CS/LE | 27 | | 0 | | Non-commercial egg supplier would cook eggs, peel, leave overnight and then deliver to the café. Positive swabs from the hard boiled eggs, kitchen and saucepan used to cook the eggs. Eggs contaminated before delivery and not refrigerated after cooking. |
| 2000 | WA | 30 | Mock ice-cream dessert (uncooked) | *S*. Typhimurium PT135 | CS/LE/Epi | 53(79) | 0 | 0 | 2C/49A/1E | Eggs direct from commercial farm. Prepared by commercial caterer in community hall kitchen for uncooked product. One food handler asymptomatic and another 2 ill, but timing unclear. |

| Year | State | ID | Vehicle (cooked/ uncooked) | Serovar/Phage Type | Investigation Methodology | No. Ill (Exposed) | No. Hospitalised | No. Fatalities | Age Distribution | Case assessment |
|---|---|---|---|---|---|---|---|---|---|---|
| 2001 | NSW | 5 | Caesar dressing, dill mayonnaise (uncooked) | *S*. Potsdam | CS/LE | 4(17) | 1 | 0 | 2C/12A/1E | Graded eggs direct from commercial farm, but *S*. Potsdam not detected from eggs or farm. Likely temp abuse of ingredients in dressing, likely sequential batches contaminated through poorly washed, non-reusable dispenser bottles, opportunity for cross-contam. of dressings and other foods. Possible for 27% of cases. People (73%) that did not eat any of the dressing were also sick. Eggs probably most unlikely source. |
| 2001 | QLD | 9 | Egg Nog (uncooked) | *S*. Heidelberg PT1 | CS | 12 | 6 | 0 | 12V | Non-commercial, raw eggs used in egg flips. Blender irregularly cleaned. |
| 2001 | SA | 17 | Mango pudding (N/A) | *S*. Typhimurium PT64 | CS | 28 | 0 | | 28 (median) | Dessert made with boiling water then placed immediately into refrigeration. Linked to asymptomatic food handler. Chinese pickled cabbage also positive. Egg source unknown. |
| 2001 | SA | 18 | Potato minced pie & rice pudding (uncooked) | *S*. Typhimurium PT135 | CS/LE | 18(38) | 3 | | 16E | Potato minced pie and rice pudding had raw non-commercial eggs (backyard) added after cooking. Commercial eggs also present. |
| 2001 | SA | 20 | Tiramisu (uncooked) | *S*. Typhimurium PT135a | CS/LE | 10(20) | 4 | 0 | 20A | Eggs from backyard hens & dessert prepared at home for a party using uncooked eggs. Also isolated from other foods served. |
| 2001 | SA | 34 | Pastry custard tart with strawberries & jelly glaze (N/A) | *S*. Typhimurium PT126 | CS/Epi | 16 | 3 | | 30.8 (median) | Case control linkage to custard tart, but unable to confirm source of infection by microbiology. Poor sanitation - glaze brush left constantly dirty & custard from piping bag returned to bulk batch & retained. “Not raw egg”; commercial |

| Year | State | ID | Vehicle (cooked/ uncooked) | Serovar/Phage Type | Investigation Methodology | No. Ill (Exposed) | No. Hospitalised | No. Fatalities | Age Distribution | Case assessment |
|---|---|---|---|---|---|---|---|---|---|---|
| 2001 | WA | 31 | Fried ice-cream (cooked) | *S*. Typhimurium PT64 | CS/LE | 38*(28) | 4 | 0 | 26 (median) | Potential for positive and asymptomatic food handler to have contaminated ice-cream. Commercial eggs used. |
| 2002 | QLD | 16 | Salmon/egg/onion/ rice patties (cooked) | *S*. Typhimurium PT135a | CS | 10 | 8 | 0 | | Undercooked salmon patties containing eggs, onion and rice stored at room temp. Egg source unknown. |
| 2002 | QLD | 37 | Egg sandwiches (cooked) | *S*. Typhimurium PT135a | CS | 12 | | | 10C/2A | Dirty eggs purchased direct from a local non-commercial egg farm. Eggs tested negative for *Salmonella* spp. However, subsequent drag swabs of the egg farm were positive for *S*. Typhimurium PT135a from 2 of the 3 sheds. |
| 2002 | QLD | 38 | Asparagus & egg dish (cooked) | *S*. Hadar PT22 | CS | 3 | 0 | 0 | 3A | All 3 cases had eaten asparagus with an egg side dish (non-commercial eggs) at the same restaurant on 12/10/02 (at different times). No microbiological evidence to confirm this food as the vehicle of infection. |
| 2002 | SA | 19 | Caesar salad (uncooked) | *S*. Typhimurium PT8 | CS/LE | 78(111) | 8 | 0 | | Outbreak associated with Caesar salad that had high TVC (830,000cfu/g). STM 8 not isolated from drag swabs from source farm. Commercial eggs purchased direct from commercial farm as well as commercial retail eggs present. Following extensive investigation, eggs considered to be least likely source. |
| 2002 | VIC | 28 | Hedgehog (uncooked) | *S*. Typhimurium PT170 | CS/LE | 9(4) | 9 | | 7.5 (median) | Eggs from backyard hens used in uncooked dessert. |

* includes person-to-person transmission as secondary infection

**Investigation Methodology**: **CS**: case series investigation:
**LE**: laboratory evidence – outbreak serovar isolated from implicated food; **Epi**: epidemiological evidence – Odds Ratio; **Age Distribution**: **C**: child; **A**: adult; **E**: elderly; **V**: vulnerable -aged care, hospital, child care

**Table 2.8: Cross-tabulation of outbreak criteria**

| | Non-Commercial | | | | | | | | | | Both | | Commercial | | | | | | | | Unknown | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Case ID** | **1[1]** | **6** | **7** | **8** | **9** | **13** | **20** | **28** | **37** | **38** | **18[2]** | **22** | **5** | **19** | **23** | **25** | **30** | **31** | **34** | **36** | **2** | **3** | **4** | **16** | **17** | **24** |
| **Serovar** | TM | H | H | TM | H | M | TM | TM | TM | Had | TM | TM | P | TM | TM | V | TM | TM | TM | TM | TM | TM | TM | TM | TM | TM |
| **PT** | 9 | 16 | 1 | 8 | 1 | | 135a | 170 | 135a | 22 | 135 | 9 | | 8 | 135 145 | 34 | 135 | 64 | 126 | RDNC A041 | 9 | 135 | 135 | 135a | 64 | U307 |
| **Food isolate** | Y | Y | | Y | | Y | Y | Y | | | Y | | Y | Y | Y | | Y | Y | | Y | | | | | | |
| **Source Invest.** | Y | Y | | Y | Y | | | Y | Y | | Y | | Y | Y | | Y | Y | | | Y | | | | | | Y |
| **Source +/-** | + | - | | - | - | | | - | + | | + | | - | - | | + | - | | | - | | | | | | + |
| **Analytical epidemiol.** | | | | | | | | | | | | Y | | | | | Y | | Y | | | Y | | | | |
| **Cracked/ Dirty** | | Y | Y | Y | | | | | Y | | | | Y | | Y | | | | | Y | | | Y | | | |
| **Cooked/ Uncooked** | U | C | U | U | U | C | U | U | C | C | U | U | U | U | U | ? | U | C | ? | C | U | C | C | C | ? | U |
| **Temp. Abuse** | Y | Y | | Y | | Y | | | | | | | Y | Y | | | | | | | | | | Y | | |
| **Vulnerable population** | | | Y | | Y | | | | Y | | Y | | | | | Y | | | | Y | Y | Y | | | | |
| **Cross-Contam.** | | Y | | Y | Y | Y | | | | | | Y | Y | Y | | Y | Y | Y | Y | | | Y | | | Y | |
| **Serovar Layer Environ** | N | N | N | N | N | Y | N | N | N | N | Y | N | N | N | Y N | Y | Y | N | N | N | N | Y | Y | N | N | N |

**Serovars** abbreviations: TM Typhimurium, H Heidelberg, M Mbandaka, Had Hadar, P Potsdam, V Virchow
**PT** Phage Type
**Food isolate**: Outbreak serovar isolated from the implicated food containing egg as an ingredient
**Source investigated**: Whether egg layer source environment investigated using drag swab for *Salmonella* detection
**Source: +/-** : Whether egg layer source *Salmonella* spp. positive or negative
**Analytical epidemiol.:** Analytical epidemiological methods demonstrated a statistically significant association with a food vehicle containing eggs as an ingredient
**Cracked/Dirty**: Either cracked or dirty eggs used for implicated food or in associated food preparation premise
**Cooked/Uncooked**: Egg or egg product in implicated food in either cooked or uncooked state
**Temperature abuse**: Investigators recorded inappropriate storage temperature for the implicated food
**Vulnerable population:** Outbreak principally affected aged care, hospital or child care cohorts
**Cross contamination**: Investigators recorded the likelihood of cross contamination from either the food preparation environment, other ingredients or food handlers
**Serovar Layer Environ**: Isolated previously from commercial layer environments in Australia; Data from NSW (Table 2.4) and Queensland investigations (Cox, 1993; Cox et al 2002) and commercial layer source investigations detailed in this Table.

[1] Both non-commercial and commercial source, but positive isolation only from backyard source
[2] Positive egg source not specified

**Table 2.9: Profile of outbreaks of Salmonellosis in vulnerable populations (aged care, hospital, child care) due to food containing eggs**

| ID | Serovar/Phage type | Investigation Methodology | Food Vehicle | Cooked/ Uncooked | Egg Source | Pop$^{n}$/ Sector | Farm Investigated? Y/N | Same serovar? Y/N | Case assessment |
|---|---|---|---|---|---|---|---|---|---|
| 2 | *S*. Typhimurium PT 9 | CS | Egg flip | uncooked | N/A | AC | N | | Raw egg flip for patients. Source of eggs unknown. |
| 3 | *S*. Typhimurium PT 135 | CSEpi | Curried egg | cooked | N/A | Retirees | N | | Spices (culture neg), added to egg after cooking; suspected as source of post-cooking contamination but usually exotic serovars. Egg source unknown. Retirees. |
| 7 | *S*. Heidelberg PT 1 | CS | Egg Nog | uncooked | NC | AC | N | | Cracked, non-commercial, raw eggs used in egg flips. |
| 9 | *S*. Heidelberg PT 1 | CS | Egg Nog | uncooked | NC | AC | Y | N | Non-commercial, raw eggs used in egg flips. Blender irregularly cleaned. |
| 18 | *S*. Typhimurium PT 135 | CS/LE | Potato minced pie & rice pudding | uncooked | NC CFRS | AC | Y | Y | Potato minced pie and rice pudding had raw backyard eggs added after cooking. Commercial eggs also present. |
| 25 | *S*. Virchow PT 34 | CS | Unknown | Unknown | PD | AC | Y | Y | Poor food handling, food handler also ill. Food vehicle not determined. Eggs purchased direct from commercial positive farm. |
| 36 | *S*. Typhimurium RDNC/A041 | CS/LE | Curried egg sandwiches | cooked | CFRS | H | Y | N | Hard-boiled eggs stored in modified atmosphere packaging. Spices untested. Commercial eggs |
| 37 | *S*. Typhimurium PT 135a | CS | Egg sandwiches | cooked | NC | CC | Y | Y | Dirty eggs purchased direct from a local non-commercial egg farm. Eggs tested negative for *Salmonella* spp. However, subsequent drag swabs of the egg farm were positive for *S*. Typhimurium PT135a from 2 of the 3 sheds. |

**Investigation Methodology**: **LE**: laboratory evidence; **Epi**: epidemiological evidence; **CS**: case series investigation
**Egg Source**: **CFRS**: commercial farm/retail system; **NC**: non commercial; **PD**: purchased direct; **N/A**: not available
**Premises**: **CFP**: commercial food premises; **PR**: private residence; **AC**: aged care; **CC**: child care; **H**: hospital

**Table 2.10: Profile of food-borne outbreaks of Salmonellosis due to foods containing eggs: where eggs were exclusively from commercially produced/graded/retail sources**

| ID | Serovar /Phage type | Investigation methodology | Food Vehicle | Premises | Age/Sector | Cooked/ Uncooked | Farm Investigated? | Same serovar? | Case assessment |
|---|---|---|---|---|---|---|---|---|---|
| 5 | *S*. Potsdam | CS/LE | Caesar dressing, dill mayonnaise | CFP | Various | uncooked | Y | N *S*. Agona Infantis Brought on | Graded eggs direct from commercial farm, but *S*. Potsdam not detected from eggs or farm. Likely temp abuse of ingredients in dressing, likely sequential batches contaminated through poorly washed, non-reusable dispenser bottles, opportunity for cross-contam. of dressings and other foods. Possible for 27% of cases. People (73%) that did not eat any of the dressing were also sick. Eggs probably most unlikely source. |
| 19 | *S*. Typhimurium PT 8 | CS/LE | Caesar salad | CFP | Various | uncooked | Y | N | Outbreak associated with Caesar salad that had high TVC (830,000cfu/g). STM 8 not isolated from drag swabs from source farm. Commercial eggs purchased direct from commercial farm as well as commercial retail eggs present. Following extensive investigation, eggs considered to be least likely source. |

| ID | Serovar /Phage type | Investigation methodology | Food Vehicle | Premises | Age/Sector | Cooked/ Uncooked | Farm Investigated? | Same serovar? | Case assessment |
|---|---|---|---|---|---|---|---|---|---|
| 31 | *S.* Typhimurium PT 64 | CS/LE | Fried ice-cream | CFP | 26 (median) | cooked | N | | Potential for positive and asymptomatic food handler to have contaminated ice cream. Commercial eggs used. |
| 34 | *S.* Typhimurium PT 126 | CS/Epi | Pastry custard tart | CFP | 30.8 (median) | N/A | N | | Case control linkage to custard tart, but unable to confirm source of infection by microbiology. Poor sanitation - glaze brush left constantly dirty & custard from piping bag returned to bulk batch & retained. "Not raw egg"; commercial |
| 36 | *S.* Typhimurium RDNC/A041 | CS/LE | Curried egg sandwiches | H | Vulnerable | cooked | Y | N | Hard-boiled eggs stored in modified atmosphere packaging. Spices untested. |

**NB**: Outbreaks 1 and 22 had eggs from a combination of commercial and non-commercial sources. Outbreak 19 had eggs from a combination of commercial and purchased direct from commercial farm.

**Investigation Methodology**: **LE**: laboratory evidence; **Epi**: epidemiological evidence; **CS**: case series investigation

**Premises**: **CFP**: commercial food premises; **PR**: private residence; **AC**: aged care; **CC**: child care; **H**: hospital

**Table 2.11: Profile of food-borne outbreaks of Salmonellosis due to foods containing eggs among other ingredients: non-commercially produced eggs (including backyard)* and commercially produced eggs sold direct off-farm (grading status unknown)****

| ID | Serovar | Investigation methodology | Food Vehicle | Premises | Cooked/ Uncooked | Layer source tested Yes/No | Farm - Same serovar? | Case assessment |
|---|---|---|---|---|---|---|---|---|
| 1* | S. Typhimurium PT 9 | CS/LE | Mayonnaise or home-made curried egg | CFP | uncooked | Y | Y | Mayonnaise kept at room temp. Eggs from both commercial and (positive) non-commercial farms |
| 6* | *S.* Heidelberg PT 16 | CS/LE | Anglaise Sauce/ Chocolate Parfait | CFP | cooked | Y | N *S.* Tennessee Mbandaka Heidelberg PT1 | Parfait served on flights between Qld & Japan. Custard prepared by subcontractor using cracked 'seconds' eggs from a non-commercial farm. Product not refrigerated properly by subcontractor. |
| 7* | *S.* Heidelberg PT 1 | CS | Egg Nog | AC | uncooked | N | | Nursing home. Cracked, non-commercial, raw eggs used in egg flips. |
| 8* | S. Typhimurium PT 8 | CS/LE | Tiramisu/ Chocolate mousse | CFP | uncooked | Y | N *S.* Tm PT64 | Uncooked dessert. Non-commercial, raw eggs, probably cracked. Inadequate cleaning and up to 5 hours on display. Also from Parmesan cheese and anchovies. |
| 9* | *S.* Heidelberg PT 1 | CS | Egg Nog | AC | uncooked | Y | N | Non-commercial, raw eggs used in egg flips. Blender irregularly cleaned. |
| 13* | *S.* Mbandaka | CS/LE | Egg & lettuce sandwiches | PR | cooked | N | | Non-commercial egg supplier would cook eggs, peel, leave overnight and then deliver to the café. Positive swabs from the hard boiled eggs, kitchen and saucepan used to cook the eggs. Eggs contaminated before delivery and not refrigerated after cooking. |
| 18* | *S.* Typhimurium PT 135 | CS/LE | Potato minced pie & rice pudding | AC | uncooked | Y | Y | Potato minced pie and rice pudding had raw backyard eggs added after cooking. Commercial eggs also present. |
| 20* | *S.* Typhimurium PT 135a | CS/LE | Tiramisu | PR | uncooked | N | | Eggs from backyard hens & dessert prepared at home for a party using uncooked eggs. Also isolated from other foods served. |

| ID | Serovar | Investigation methodology | Food Vehicle | Premises | Cooked/ Uncooked | Layer source tested Yes/No | Farm - Same serovar? | Case assessment |
|---|---|---|---|---|---|---|---|---|
| 23** | *S.* Typhimurium PT135 & PT145 | CS/LE | Gelati | CFP | uncooked | N | | Egg yolk heated to 80°C, cooled at room temp., whites added post-cooking. Cracked eggs supplied direct from commercial farm. |
| 24 | *S.* Typhimurium U307 | CS | Mayonnaise | CFP | uncooked | Y | Y egg washings | Mayonnaise, using whole raw egg, supplied by catering wholesaler. Egg source unknown |
| 25** | *S.* Virchow PT 34 | CS | Unknown | AC | Unknown | Y | Y | Poor food handling, food handler also ill. Food vehicle not determined. Eggs purchased direct from positive commercial farm. |
| 28* | *S.* Typhimurium PT 170 | CS/LE | Hedgehog | PR | uncooked | Y | N | Eggs from backyard hens used in uncooked dessert. |
| 30** | *S.* Typhimurium PT 135 | CS/LE/Epi | Mock ice-cream dessert | CFP | uncooked | Y | N | Eggs direct from commercial farm. Prepared by commercial caterer in community hall kitchen for uncooked product. One food handler asymptomatic and anther 2 ill, but timing unclear. |
| 37* | *S.* Typhimurium PT 135a | CS | Egg sandwiches | CC | cooked | Y | Y | Dirty eggs purchased direct from a local non-commercial egg farm. Eggs tested negative for *Salmonella* spp. However, subsequent drag swabs of the egg farm were positive for *S*. Typhimurium PT135a from 2 of the 3 sheds. |
| 38* | *S.* Hadar PT22 | CS | Asparagus & egg dish | CFP | cooked | N | | All 3 cases had eaten asparagus with an egg side dish (non-commercial eggs) at the same restaurant on 12/10/02 (at different times). No microbiological evidence to confirm this food as the vehicle of infection. |

**Investigation Methodology**: **LE**: laboratory evidence; **Epi**: epidemiological evidence; **CS**: case series investigation
**Premises**: **CFP**: commercial food premises; **PR**: private residence; **AC**: aged care; **CC**: child care; **H**: hospital

**Table 2.12: Reported isolations of *Salmonella* Typhimurium (STm) and STm PT135 from leading sources between 1998 – 2002 (NEPSS non-human data )**

| Source | 1998 | | 1999 | | 2000 | | 2001 | | 2002 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | STm | STm 135 | STm | STm 135 | STm | STm 135 | STm | STm 135 | STm | STm 135 |
| Bovine | 330 | 27 | 290 | 23 | 292 | 16 | 288 | 26 | 299 | 31 |
| Beef | 5 | | 15 | 2 | 3 | | 6 | 1 | 9 | |
| Ovine | 17 | 6 | 22 | 11 | 8 | 2 | 23 | 9 | 25 | 8 |
| Lamb /mutton | 16 | 5 | 8 | 3 | 10 | 1 | 11 | 2 | 4 | 2 |
| Chickens | 3 | | 23 | 6 | 2 | | 16 | 1 | 15 | 13 |
| Chicken meat | 75 | 4 | 81 | 13 | 39 | 11 | 166 | 28 | 118 | 20 |
| Other poultry | 39 | | 35 | | 15 | 2 | 18 | 4 | 7 | |
| Poultry meat | 3 | | 22 | | | | 43 | | 14 | |

## 2.4 *Salmonella* Enteritidis (SE) Status in Australia

Over the past 5 years, follow-up on national isolates of SE PT4 reported to NEPSS has resulted in 73-86% (Table 2.13) reported as associated with recent overseas travel histories (NEPSS Human Annual Reports 1998-2002). Inability to obtain travel histories for many cases creates the impression that there is substantial evidence for locally acquired SE. However, there is only limited evidence for acquisition of SE PT4 cases. The breakdown of phage types of SE cases show that the majority of cases with no history of recent overseas travel prior to the onset of their illness are due to PT26, 82% of which have been reported from Queensland since 1991 when phage typing of SE began.

**Table 2.13: *S*. Enteritidis PT4 cases in Australia 1998-2002 (NEPSS Human Annual Reports)**

| Year | Total SE cases | SE cases reported to NEPPS as overseas acquired | Total SE PT4* cases | SE PT4* cases reported to NEPPS as overseas acquired | Local SE PT4 cases** ( %.) |
|---|---|---|---|---|---|
| 1998 | 380 | 225 | 239 | 175 | 6 (2.5%) |
| 1999 | 368 | 204 | 201 | 152 | 6 (3.0%) |
| 2000 | 248 | 147 | 115 | 86 | 5 (4.3%) |
| 2001 | 294 | 187 | 101 | 81 | 1 (1.0%) |
| 2002 | 305 | 197 | 108 | 93 | 2 (1.9%) |

* SE PT4 and PT4b combined for 2001 and 2002 totals
****** positively reported as locally acquired (no overseas travel J Powling NEPSS 2003)
( % ) Local SE PT4 cases as a proportion of total SE PT4 cases

In addition, since 1998, the Victorian Department of Human Services (DHS) has actively followed up all notified Victorian cases of SE, to determine if infection was acquired overseas or locally. The number cases of SE notified in Victoria each year from 1998 to 2002 and the percentage of cases associated with overseas travel is presented in Table 2.14.

**Table 2.14: Number of *Salmonella* Enteritidis cases and those associated with overseas travel reported in Victoria for the period 1998-2002. (Source – Surveillance of Notifiable Infectious Diseases in Victoria 1998 – 2001 and Victorian OzFoodNet annual report 2002)**

| Year | Overseas acquired cases | Total cases with travel history known | Total cases | % Overseas/Total with known travel history |
|---|---|---|---|---|
| 1998 | 58 | 62 | 67 | 94% (58/62) |
| 1999 | 57 | 60 | 60 | 95% (57/60) |
| 2000 | 30 | 33 | 35 | 91% (30/33) |
| 2001 | 44 | 50 | 51 | 88% (44/50) |
| 2002 | 45 | 45 | 47 | 100% (45/45) |

Efforts to clarify the source of SE infection are continuing. In October 2001, OzFoodNet commenced a case control study of sporadic, locally acquired SE infection to investigate risk factors associated with acquiring SE in Australia. States participating in this study include Queensland, South Australia, Tasmania, Victoria, Western Australia, and five Public Health Areas within New South Wales. This study covers approximately 75% of the Australian population (Joy Gregory, DHS (Vic), pers comm, 2003).

Since October 2001, 325 cases of SE have been identified. Travel history was obtained for 285 cases. Of these, 78% (221/285) of these infections were acquired overseas. Although these data are preliminary and may be subject to amendment, the results indicate that 22% of infections are not acquired overseas. The majority of cases with no travel history were SE phage type 26 (Table 2.15), a phage type endemic to northern Queensland but also acquired occasionally by travellers to Fiji. Two cases (Phage type 28 and Phage type 1) had a history of close household contact with a recent overseas traveller.

Between October 2001 and March 2003, there have been 41/64 cases of non-overseas travel associated SE enrolled in the case control study. The study is due to conclude in October 2003, after which the data will be analysed and published.

**Table 2.15: *Salmonella* Enteritidis Phage Types for Australian cases with no overseas travel history. (n=64) (Joy Gregory, VDHS, pers comm, 2003)**

| Phage Type | Number of cases |
|---|---|
| 26 | 38 (60%) |
| RDNC | 7 (11%) |
| untypable | 6 (9%) |
| 4b | 3 (5%) |
| 1b | 2 (3%) |
| 19a | 2 (3%) |
| 4 | 2 (3%) |
| 28 | 1 (1.5%) |
| 14 | 1 (1.5%) |
| 1 | 1 (1.5%) |
| unknown | 1 (1.5%) |

Historically SE PT26 has been isolated from Queensland flocks (Table 2.16) and not from other Australian layer flocks (Table 2.4). Cox (1993) reported that local strains of SE do not differ markedly in their biology or pathogenicity from foreign endemic strains and postulated that Australian layer varieties may be less susceptible to infection with SE. However, in mice SE PT 26 is reported to be less virulent than SE PT 4 (Cox 1993). Nevertheless, the history of SE PT26 as a widespread regional contaminant in northern Queensland highlights the need for constant vigilance.

In Tasmania at Easter 2000 4 human cases were diagnosed with SE PT4. Two of the human cases were linked by ingestion of eggs originating from a commercial poultry farm in Tasmania. The SE isolated from environmental drag swabs on the farm has been typed at Melbourne Diagnostic Unit and given a provisional designation of PT4 variant. The isolates have been forwarded to Colindale, UK for confirmation of their final designation. The cause of the outbreak remains unconfirmed. The *Salmonella* positive environmental samples were found in 3 sheds (out of 13 tested) in July 2000 and in one of the 3 sheds in February 2001 (Table 2.16). No *Salmonella* were isolated from environmental drags swabs taken from free-range sheds. On 3 separate occasions, 60 birds were selected from the *Salmonella* positive environmental sheds. On 2 occasions, at 6 months intervals, SE was detected serologically in 4 birds (1 in Nov 2000 and 3 in June 2001) using an ELISA test. However, SE was not isolated from any of these birds. A positive ELISA result was found after repeated sampling of the individual birds. Although SE was not isolated from birds in this case, the positive ELISA assays do indicate prior infection by SE.

Subsequently, SE was not detected in 10 Tasmanian layer farms tested by the drag swab method between August and September 2000. This case highlights the potential risk confronting the egg industry in Australia, where the odd bird on the odd farm in the odd corner of Australia could be infected with SE but go unnoticed. Unless the status of the flock is discovered early, establishment of SE in flocks could have serious economic and public health impact.

**Table 2.16: *Salmonella* Enteritidis isolated from chicken, chicken products and chicken farm sources in Australia 1979-2001**

| Year | State | Source(s) | | | Phage type | Reference |
|---|---|---|---|---|---|---|
| 1979-1983 | Qld | chicken | chicken litter | | not done | MacKenzie 1991, AVA Conference Sydney |
| 1984 | Qld | egg products | | | " | |
| 1990 | Qld | chickens | egg pulp | intestinal contents | untypable | IMVS Oct 1990, Mackenzie 1991 |
| 1991 | Qld | | | Avian? (chicken? caecum) | untypable | IMVS 1991 Annual Report |
| 1992 | Qld | Chicken litter | | | 26 | IMVS, 92 Annual Report |
| 1993 | Qld | Chicken litter | Chicken feed | | RDNC | NEPSS, Non-human Annual Report 1993 |
| 1993 | Qld | | chicken meat | chicken feed | 26 | IMVS Dec93 and IMVS 93 Annual Report |
| 1995 | Qld | meat chicken | chicken litter* | | 26,1* | IMVS 95, |
| 1996 | Qld | | egg white | . | 9 | IMVS 96 |
| 1997 | NSW<br>Vic | chicken meat | backyard chickens*+ | internal organs | 26<br>RDNC (5a)* | IMVS 97<br>Vic PHLG 97 |
| 2000 | **Tas | | chicken litter | | 4 var (provisional typing result) | #Animal quarantine Policy Memorandum 2001/16 & D. Lightfoot (pers. comm.) MDU, Vic |

1. *Asterisks identify sources and corresponding phage type
2. In 1993, SE phage type 4 was reported as isolated from layer chicken faeces in Queensland. Subsequent follow-up work indicated the identification of a SE phage type 4 was a result of laboratory cross contamination from experimental mice in the laboratory. Therefore this isolation was not included in the table.
3. + The backyard flock became infected from human sources hospitalised with clinical SE PT5a, following overseas travel
4. ** Part of investigations following four human cases of SE PT4 not associated with travel

(Source: G Arzey. Based on a table presented by G Arzey at the Poultry Information Exchange Surfers Paradise Australia April 2002 pending final designation by Colindale, UK)

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# Appendix 3
# Egg Production Questionnaire: On-farm Handling and Production Practices

*Ben Daughtry, George Arzey, Frank Gardiner*

## 3.1 Introduction

This survey was used to gather information on various production and handling procedures and management practices in the Australian egg industry, necessary for the development of a quantitative risk assessment of *Salmonella* in eggs. The survey was not intended to be a comprehensive survey of all production practices and flock management issues in Australia.

Information regarding flock size, egg collection, storage and distribution practices were gathered by a producer questionnaire. The survey was undertaken in four states, principally NSW, Qld and SA, with a small number of flocks from Victoria. Members of the risk assessment group and a private consultant developed the farmer questionnaire and conducted the survey by telephone interview.

Data collected in this report forms part of a RIRDC funded risk assessment for *Salmonella* spp. in the Australian egg production system (Project SAR-42A).

## 3.2 Methods

The survey was biased to include alternative production systems (*eg* Barn and Free range systems).

### Collection of Farm and Processor data

Information describing production of eggs under Australian conditions has been obtained using questionnaires specific for egg producers and processors in Australia. This information has been collated and relevant data extracted using techniques described below.

### Farm production data

The farm production questionnaire covered the steps involved from the laying of the egg, through egg collection, on-farm storage and transportation to egg grading facilities. The aim was to obtain ranges of values for key parameters and variables. This is important in determining the range of values to be included in the quantitative risk assessment model. Information was gathered by telephone, or direct interview on farm by G. Arzey (NSW Agriculture), F. Gardner (private consultant) and G. Parkinson (Victorian NRE). Growers from NSW (20), Victoria (3) Queensland (25) and South Australia (25) were included in the survey. The survey in these four states covered over 4.2 million layers, with flock sizes ranging from 300 to over 630000 birds. Producers using alternative production systems (eg barn and free range) were also included in the survey.

Data was extracted using the following methodology:

- Data was tabulated for each grower by the interviewer.
- All completed questionnaires were sent to B. Daughtry for data collation. The interviewer was contacted to query unusual or suspect values identified during collation.
- Statistical and graphical summaries for each question were prepared, both by farm site and by flock size for comparison.
- Dependency between variables was investigated using graphical methods.

## Questionnaire

Dear Producer/Farm Manager

As part of an Egg Industry funded project assessing the egg in Australia as a safe food item we are seeking information in relation to egg handling and storage on farms in Australia.

We need 5-10 minutes of your time to answer 16 questions. The answers will provide us with very useful information on egg handling and storage in Australia. Your answers will remain confidential. You do not need to fill in your name or the farm name. The aim of the survey is not to find faults but rather to give the project a greater understanding of the diversity of egg handling practices in Australia. Some of the questions you may not be able to answer. For example, question 1, if your egg collection system is a manual system or question 5, if your egg collection system is an automated system.

Farm Location ………………………Phone $N^0$ (Optional)…………..

| Farm Size | Type of production (barn, free range, cages) | Shed age structure (single age/multi-age) |
|---|---|---|
| …………. | …………………. | ………………….. |

**Please answer the following questions** (There are no right or wrong answers).

1. If your egg system is **automated** how many times per day are the eggs sorted and how long does it take for the eggs to reach the egg storage room from the time the egg has been laid?
   **Answer**
   a. Number of times egg are sorted each day………………..
   b. Minimum time (hours) Average (hours) Maximum time (hours)
   c. I do not have an automated egg collection system ………. .

2. If your egg collection system is automated how long (hours) does it take eggs that missed the sorting on the day (eggs laid after collection finishes) to reach the storage room the next day?
   **Answer**
   Minimum time …….Average ……… Maximum time …..

3. If your collection system is a **manual** system how many times each day do you collect the eggs?
   **Answer**
   Once Twice More

4. Do you collect eggs during the weekend or public holidays?
   **Answer**
   Egg collected every day including weekends and public holidays……
   Eggs are not collected during the weekend……
   Eggs are not collected on Sunday……..
   Eggs are not collected on public holidays………

5. If your collection system is a manual system, how long (in hours) does it take from egg collection until the eggs reach the storage room?
   **Answer**
   Minimum time ……. Average ……….maximum time ….

6. If your egg collection system is a manual system, how long (hours) does it take eggs that missed the collection on the day (eggs laid after collection finishes) to reach the storage room the next day?
   **Answer**

Minimum time ….….Average …..…..Maximum time …………

7. How long are eggs held in storage on the farm?
**Answer**
Time eggs are held in storage on the farm: Minimum …... Average …….. Maximum…….

8. At what temperatures are the eggs kept during storage on the farm?
**Answer**

| | | | |
|---|---|---|---|
| ***In summer*** | Minimum | Average | Maximum |
| ***In Winter*** | Minimum | Average | Maximum |

9. **a.** What distances do the eggs travel from the farm to the furthest next point of storage or sale?
**b.** How long do they spend in transport?
**Answer**: a. Furthest distance …………..
b. Transport time Minimum ……. Maximum …….Average ..…..

10. At what temperatures are your eggs transported to the next point of storage or sale?
**Answer**
Temp controlled vehicle ……. Deg C……..
Vehicle only insulated …………
Not in a temperature controlled vehicle ……..

11. **If the vehicle is refrigerated** is the unit operational all the time or only when the outside temperature is high?
**Answer**
Operational all the time …….
Operational only when the temperature outside is high ……..

12. Are your eggs washed on the farm or off the farm (eg egg grading facility)
**Answer**
Not washed …... Washed off the farm …… Washed on the farm……
All eggs are washed …..
Only soiled eggs are washed …..
Other: please specify …..

13. Do you remove dirt from eggs by a knife, abrasive material like scotchbrite or wet cloth?
**Answer**
Do not remove dirt …..
Remove with …….

14. If you market the eggs yourself what is the period of time you specify on the 'best before date' from **date of lay**
**Answer**
1 week 2 weeks 4 weeks 5 weeks 7 weeks 10 weeks other

15. How often do you practice moult inducement?
**Answer**
Every batch ….. Not every batch .…. Only as a last resort ….. Never …..

16. What is the age of the oldest batch of layers on the farm?

**Thank you for your time and good will**

George Arzey
Senior Veterinary Officer Poultry

## 3.3 Questionnaire Summary of Results

The egg production survey covered a total of 73 producers with a total combined flocksize of over 4 million layers.

### 3.3.1 Sample profile

**Table 3.1: Number of farm sites by state and total flock size**

| State | Number of farm sites | Flocksize (millions) |
|---|---|---|
| NSW | 20 | 1.550 |
| Qld | 25 | 1.861 |
| SA | 25 | 0.583 |
| Vic* | 3 | 0.212 |
| **Total** | 73 | 4.206 |

* One Victorian grower did not respond

**Table 3.2: Breakdown of farm sites by flock size**

| State | <10 k | >10 to 20 k | > 20 to 50 k | >50 k | Total (by state) |
|---|---|---|---|---|---|
| NSW | 1 | 4 | 6 | 9 | 20 |
| Qld | 6 | 5 | 9 | 5 | 25 |
| SA | 12 | 7 | 3 | 3 | 25 |
| Vic* | 0 | 1 | 0 | 1 | 2 |
| **Total (by flock size)** | 19 | 17 | 18 | 18 | 72 |
| Total (%) | 26.4 | 23.6 | 25.0 | 25.0 | |

* One Victorian grower did not respond

**Table 3.3: Average flock size by state**

| NSW | Qld | SA | Vic | All states |
|---|---|---|---|---|
| 77 500 | 74 400 | 23 300 | N/A | 58 400 |

### 3.3.2 Production System

**Table 3.4: Number of types of production systems on a farm site (N=73)**

Single (Caged, Barn laid or Free Range) or multiple production system used on farm site

| Production systems | Percentage of farm sites |
|---|---|
| Single system | 80.8 |
| Multiple system | 19.2 |
| **Total** | **100.0** |

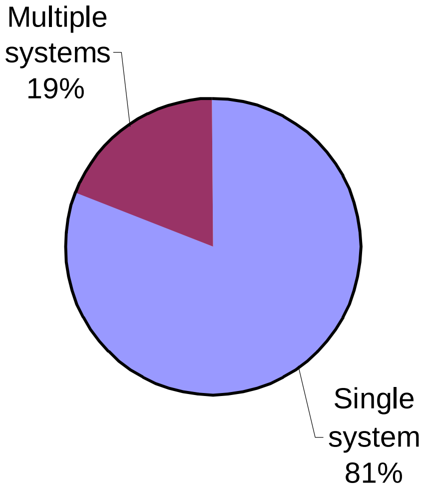



**Table 3.5: Type of production system (N=72)**

| Production systems | Percentage of farm sites |
|---|---|
| Caged only | 65.3 |
| Barn laid only | 4.2 |
| Free range only | 13.9 |
| Caged + other(s)* | 15.3 |
| Barn + Free range | 1.4 |
| Total | 100.1 |

* three producers reported using all three (Caged, Barn and Free range) production systems

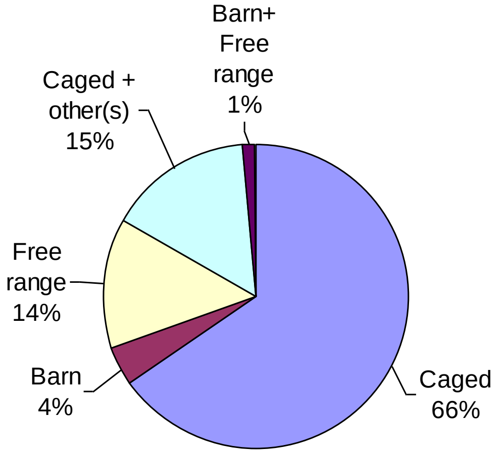
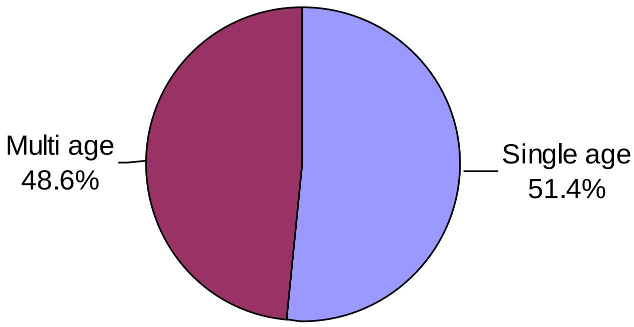


**Table 3.6: Flock size by Production system (N = 79)**

| | Percent of flocks | | |
|---|---|---|---|
| **Flock size** | **Free range** | **Barn** | **Cage** |
| <10000 | 9.9 | 7.4 | 11.1 |
| 10000 to 19999 | 3.7 | 2.5 | 19.8 |
| 20000 to 50000 | 2.5 | 2.5 | 19.8 |
| more than 50000 | 1.2 | 1.2 | 18.5 |
| **Total** | **17.3** | **13.6** | **69.2** |

**Table 3.7: Shed age structure (N=72)**

| **Age profile of flocks** | **Percentage of farm sites** |
|---|---|
| Single age | 51.4 |
| Multi age | 48.6 |
| **Total** | **100.0** |



### 3.3.3 Egg Collection

**Table 3.8: Type of egg collection system (N = 73)**

| Egg collection system | Percentage of farm sites |
|---|---|
| Manual collection | 58.9 |
| Automated collection | 21.9 |
| Both Automatic and Manual | 19.2 |
| **Total** | **100** |

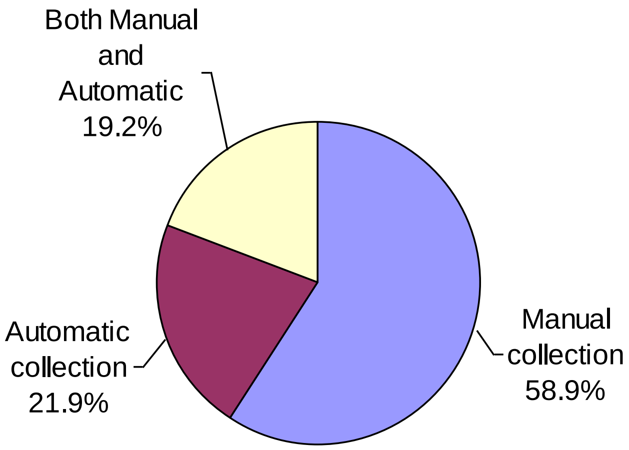



**Table 3.9: Egg collection – days (N = 73)**

| Egg collection | Percentage of farm sites |
|---|---|
| Everyday | 93.2 |
| Not Sunday | 2.7 |
| Not Sunday or Public Holidays | 2.7 |
| Not Christmas | 1.4 |
| **Total** | **100.0** |

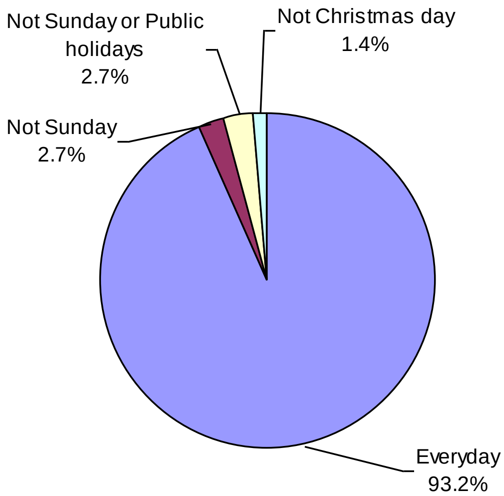


**Table 3.10: Egg collection – number of times per day**

| Collections per day | Manual Collection | Automated Collection |
|---|---|---|
| 1 | 21.1 | 51.7 |
| 2 | 57.9 | 44.8 |
| 3 | 15.8 | 3.4 |
| 4 | 5.2 | 0.0 |
| **Total** | **100.0** | **100.0** |

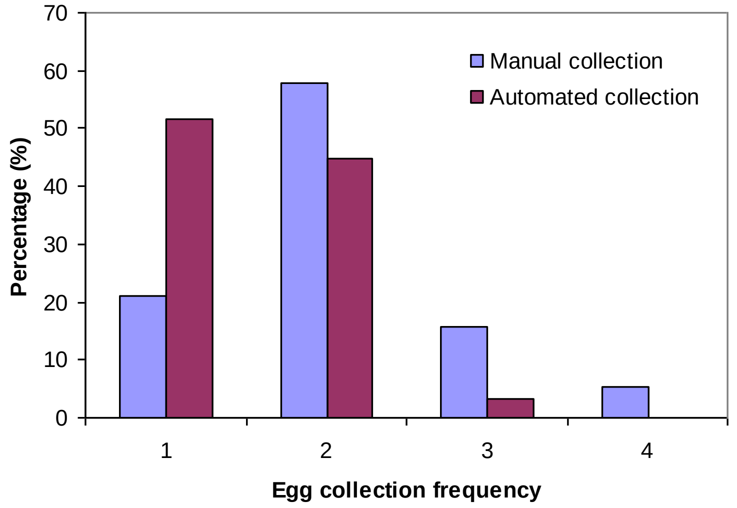



**Table 3.11: Time for eggs to reach the store room after collection**

| Time to reach store room | Manual Collection | Automated Collection |
|---|---|---|
| <1 h | 33.9 | 10.7 |
| 1 to <2 h | 17.9 | 21.4 |
| 2 to <3 h | 19.6 | 25.0 |
| >3h | 28.6 | 42.9 |
| **Total** | 100.0 | 100.0 |

The largest most likely time reported time for eggs that have been collected to reach the storeroom is 7 hours.

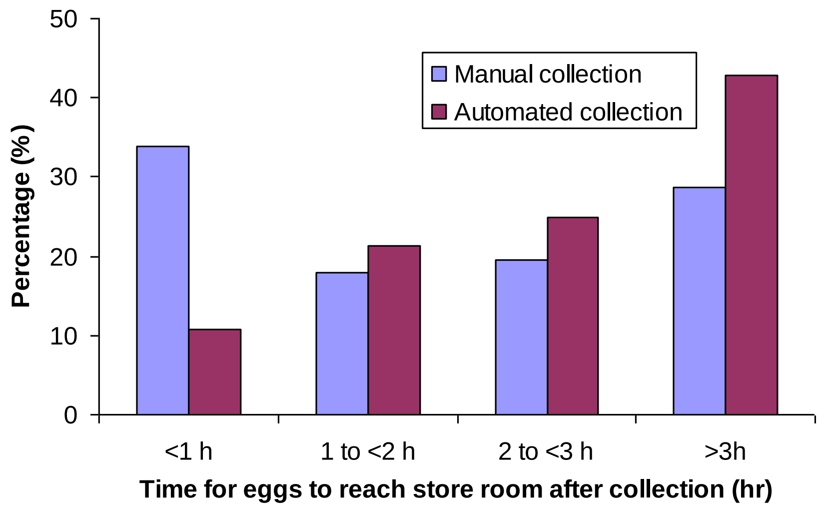


**Table 3.12: Egg holding on farm (using average / most likely value only) (N = 73)**

| On-farm storage time | Percentage of farm sites |
|---|---|
| <1 day | 8.2 |
| 1 to <2 days | 17.8 |
| 2 to <3 days | 31.5 |
| 3 to <4 days | 35.6 |
| >4 days | 6.8 |
| **Total** | **100.0** |

*The maximum reported time that eggs were stored on farm was 336 hours (14 days).*

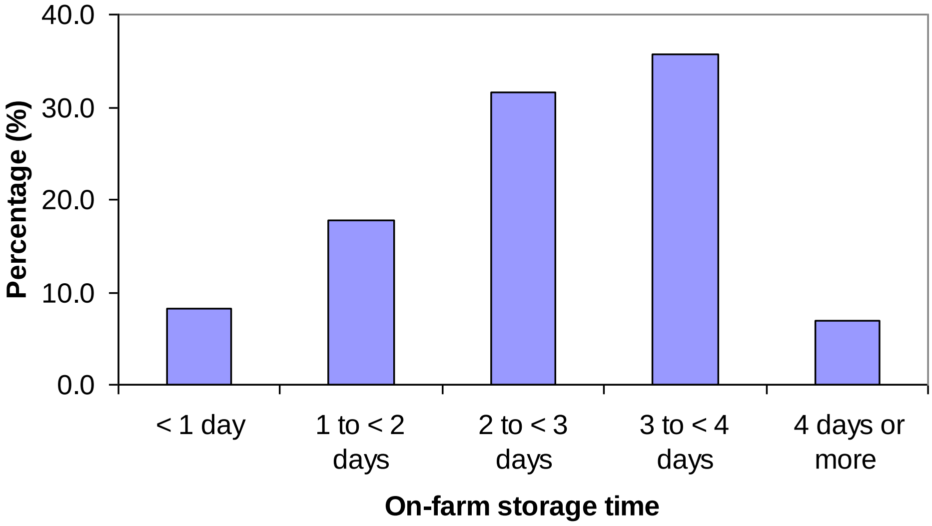
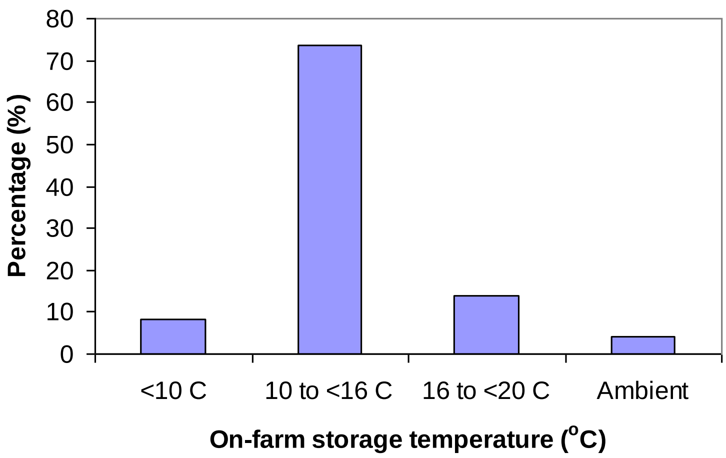



**Table 3.13: Egg holding temperature average (summer) (N = 72)**

| On-farm storage temperature | Percentage of farm sites |
|---|---|
| <10°C | 8.3 |
| 10 to <16°C | 73.6 |
| 16 to <20°C | 13.9 |
| Ambient | 4.2 |
| **Total** | **100.0** |



### 3.3.4 Transportation

**Table 3.14: Egg transportation – Temperature control of vehicle (N = 71)**

| Temperature control | Percentage of farm sites |
|---|---|
| Temperature controlled at all times | 38.0 |
| Temperature controlled at high ambient | 22.5 |
| Not temperature controlled | 26.8 |
| Unknown | 12.7 |
| **Total** | **100.0** |

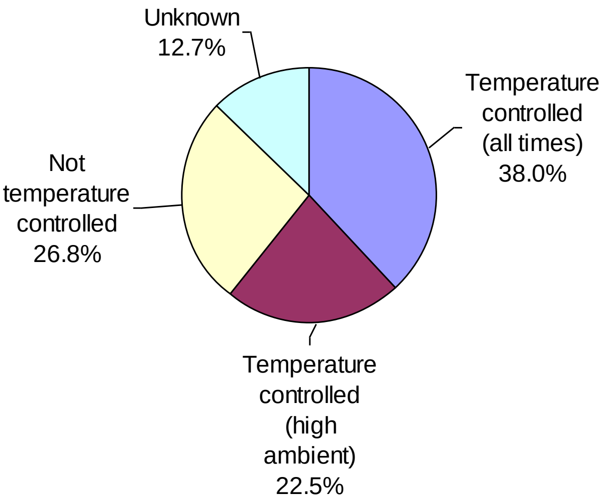



**Table 3.15: Egg transportation – Temperature when cooling used (N = 55)**

| Transportation temperature (°C) | Percentage of farm sites |
|---|---|
| <10 °C | 1.8 |
| 10 to < 16°C | 47.3 |
| 16 to <20°C | 41.8 |
| >20°C | 5.5 |
| Unknown | 3.6 |
| **Total** | **100.0** |

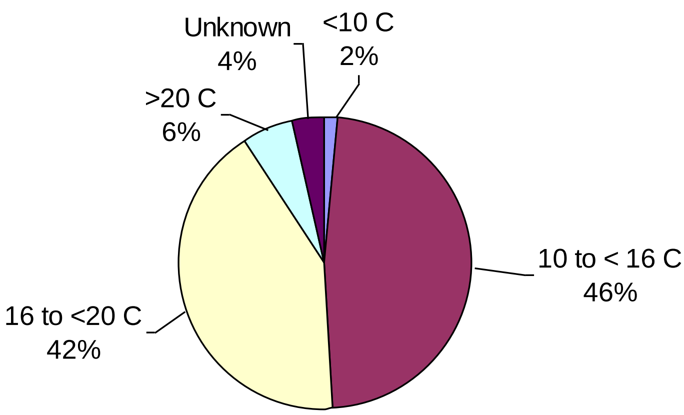


**Table 3.16: Egg transportation – time taken to travel from the farm to the furthest next point of storage or sale**

| Transportation time (hours) | Percentage of farm sites |
|---|---|
| <1 h | 8.3 |
| 1-2 hours | 41.7 |
| 2-3 hours | 33.3 |
| 3-4 hours | 10 |
| >4 hours | 6.7 |

*The longest reported transportation time off-farm was 48 hours.*

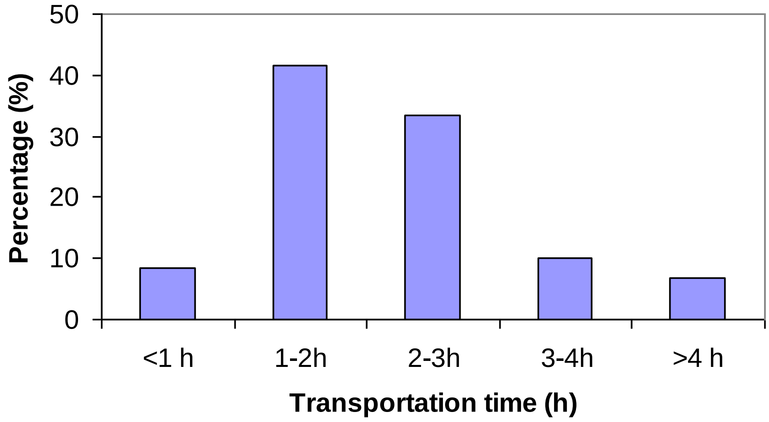
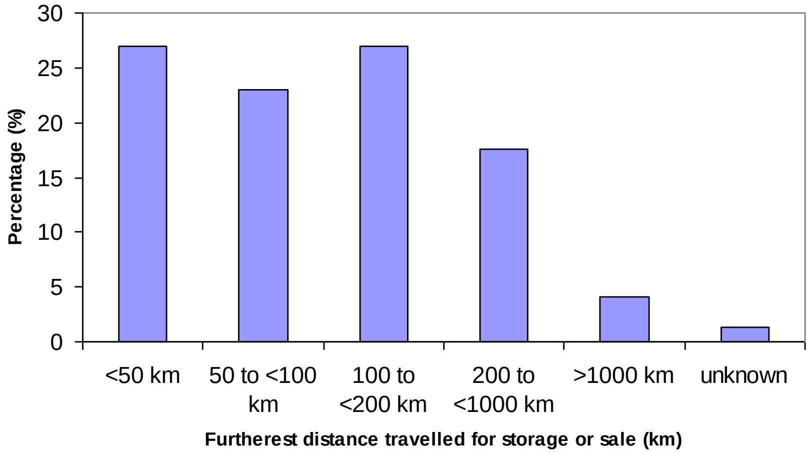



**Table 3.17: Egg transportation – furthest distance travelled from the farm to the furthest next point of storage or sale (N = 74)**

| Furthest distance travelled | Percentage of farm sites |
|---|---|
| <50 km | 27.0 |
| 50 to <100 km | 23.0 |
| 100 to <200 km | 27.0 |
| 200 to <1000 km | 17.6 |
| ≥1000 km | 4.1 |
| unknown | 1.3 |
| **Total** | **100.0** |

*The longest reported distance for eggs transported off-farm was 1200 km.*



### 3.3.5 Washing and dirt removal

**Table 3.18: Egg washing (N = 72)**

Responses for this question were combined into three categories: (1) combining "Not washed" with "Washed off-farm" to cover unwashed eggs; (2) combining "washed on-farm" and "All eggs washed" to cover all washed eggs; and (3) "only soiled washed"

| Egg washing | Percentage of farm sites |
|---|---|
| Eggs not washed | 45.8 |
| All eggs washed on farm | 20.8 |
| Only soiled eggs washed on-farm | 33.4 |
| **Total** | **100.0** |

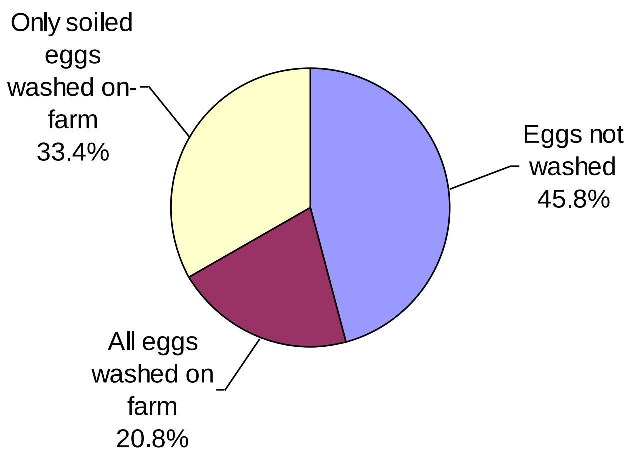



**Table 3.19: Dirt removal (N = 68)**

| Dirt removal | Percentage of farm sites |
|---|---|
| Yes | 65.7 |
| No | 34.3 |
| **Total** | **100.0** |

*Some producers reported segregation of eggs (eg sending to pulping, rather than cleaning)*

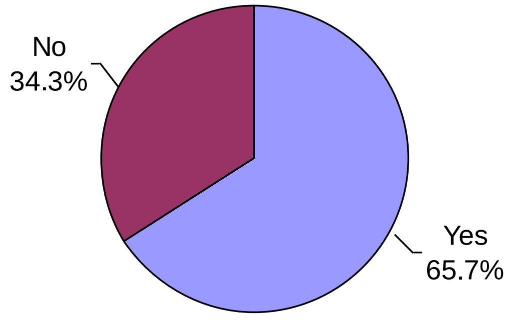
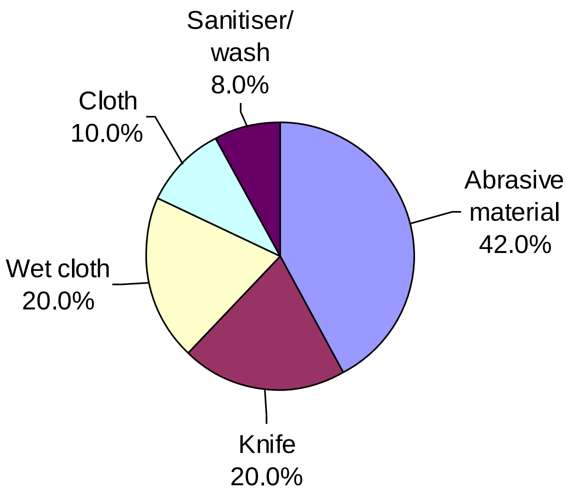


**Table 3.20: Dirt removal – methods used (N = 50)**

More than one method may be used on a farm

| Dirt Removal Method | Percentage of farm sites |
|---|---|
| Abrasive material | 42.0 |
| Knife | 20.0 |
| Cloth | 10.0 |
| Wet cloth | 20.0 |
| Sanitiser/ wash | 8.0 |
| **Total** | **100.0** |



### 3.3.6 Miscellaneous

**Table 3.21: Best before date for eggs sold off-farm (N=68)**

| Best before date | Percentage of farm sites |
|---|---|
| 3 wk | 4.4 |
| 4 wk | 25.0 |
| 5 wk | 57.4 |
| 6 wk | 13.2 |
| **Total** | **100.0** |

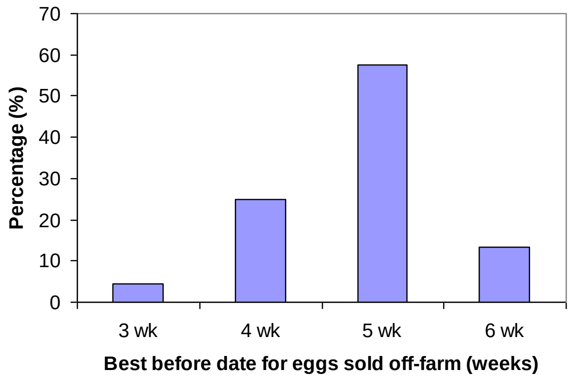



**Table 3.22: Age of oldest batch of layers on farm (N = 73)**

| Age of layers | Percentage of farm sites |
|---|---|
| <52 weeks | 11 |
| 52 to <78 weeks | 47.9 |
| 78 to 104 weeks | 27.4 |
| >104 weeks | 13.7 |
| **Total** | **100.0** |

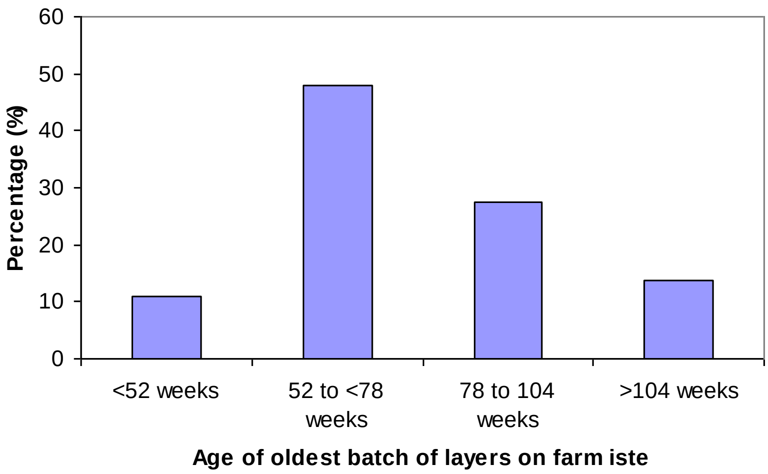
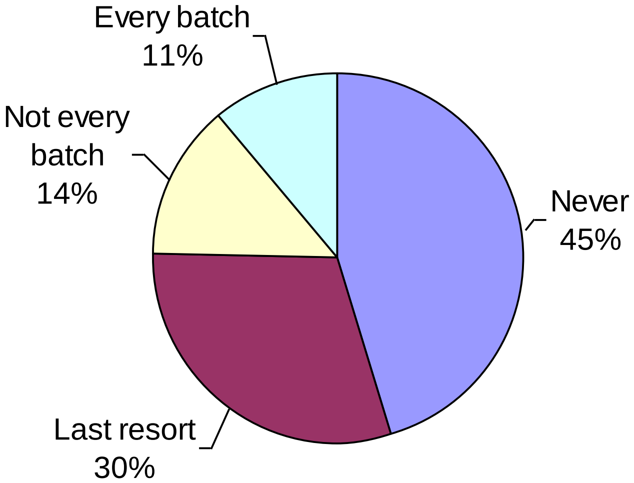


**Table 3.23: Moulting practice (N = 73)**

| Moulting | Percentage of farm sites |
|---|---|
| Never | 45.2 |
| Last resort | 30.1 |
| Not every batch | 13.7 |
| Every batch | 11.0 |
| **Total** | **100.0** |



# Appendix 4
# Exposure Assessment Model Inputs

**Table 4.1: Full list of on–farm collection, distribution and handling conditions for shell eggs. These factors were used as inputs for development of the EA model.**

| Model input | Distribution | Values | Data source |
|---|---|---|---|
| ***Salmonella* prevalence and growth behaviour** | | | |
| *Salmonella* egg contents prevalence | Beta(α,β) | α = 1, β = 20001 | (1) SARDI (2003) |
| | Beta(α,β) | α = 3, β = 83819 | (2) de Louvois (1994) |
| | Beta(α,β) | α = 11, β = 139991 | (3) Saeed (1998) |
| | Beta(α,β) | α = 23, β = 646979 | (4) Schlosser *et al*. (1999) |
| | Beta(α,β) | α = 17, β = 284700 | (5) Shirota *et al*. (2001) |
| | Beta(α,β) | α = 1, β = 12541 | (6) Wilson *et al*. (1998) |
| | Discrete | {1,2,3,4,5,6}, {0.017,0.071,0.118, 0.544,0.239,0.011} | |
| | | | |
| Number of *Salmonella* per egg when laid | Poisson | 7, truncated at 0 | Opinion based on behaviour of *S*. Enteritidis |
| Growth of *Salmonella* in 24 after lay | Pert(a, b, c) | a = 0, b = 1, c = 1.5 | FAO-WHO (2002) |
| Maximum number of *Salmonella* per egg | Pert(a, b, c) | a = 8, b = 9, c = 10 | Literature eg Humphrey (1989) |
| *Growth rate ($h^{-1}$)* | | | |
| Optimum growth rate, $k_{opt}$ ($h^{-1}$) | constant | 0.7039 | after Oscar (2002) |
| Minimum growth temperature (°C) | constant | 5.567 | |
| Optimum growth rate (°C) | constant | 39.756 | |
| Maximum growth rate (°C) | constant | 49.59 | |
| Mean squared error | Normal(μ, σ) | μ = 0, σ = 0.02997 | |
| | | | |
| *Yolk mean time,* YMT (days) | | | Whiting *et al.* (2000) |
| Intercept | constant | 2.0805 | |
| Slope | constant | -0.04217 | |
| Mean squared error | Normal(μ, σ) | μ = 0, σ = 0.1524 | |
| | | | |
| **On-farm** | | | |
| Layer hen temperature (°C) | constant | 41.2 | Richie *et al*. (1994) |
| Time of day that egg is layed | cumulative | (9, 11, 13, 15), (0.177, 0.462, 0.735, 0.93), minimum = 6, maximum = 17 | Romanoff and Romanoff (1949) |
| Layer shed temperature (°C) | Normal(μ, σ) | μ = 24, σ = 2 | |
| Cooling rate constant ($h^{-1}$) | Pert(a, b, c) | a = 0.8, b = 0.9, c = 1 | USDA-FSIS (1997) |
| Time to reach storeroom after collection (h) | | | |
| Worst | Triangle(a,b,c) | a = 1, b = 4, c = 10 | Survey data (Appendix 3) |
| Median | Uniform(a, c) | a = 1, c = 3 | Survey data (Appendix 3) |
| Best | Triangle(a,b,c) | a = 0.1, b = 0.2, c = 1 | Survey data (Appendix 3) |

| | | | |
|---|---|---|---|
| Storage temperature on-farm (°C) | | | |
| Worst | Normal(μ, σ) | μ = 26, σ = 3 | Survey data (Appendix 3) |
| Median | Uniform(a, c) | a = 13, c = 16 | Survey data (Appendix 3) |
| Best | Uniform(a, c) | a = 4, c = 10 | Survey data (Appendix 3) |
| Cooling rate constant ($h^{-1}$) | Pert(a, b, c) | a = 0.0528, b = 0.08, c = 0.1072 | USDA-FSIS (1997) |
| | | | |
| **Transportation off-farm** | | | |
| Temperature during off-farm transportation (°C) | | | |
| Worst | Normal(μ, σ) | μ = 26, σ = 3 | Survey data (Appendix 3) |
| Median | Uniform(a, c) | a = 14, b = 18 | Survey data (Appendix 3) |
| Best | Uniform(a, c) | a = 10, b = 12 | Survey data (Appendix 3) |
| Transportation time (h) | LogNormal(μ, σ) | μ = 2, σ = 1 | Survey data (Appendix 3) |
| Cooling rate constant ($h^{-1}$) | Pert(a, b, c) | a = 0.0528, b = 0.08, c = 0.1072 | USDA-FSIS (1997) |
| | | | |
| **Processing at grading floor** | | | |
| Storage temperature before processing (°C) | Normal(μ, σ) | μ = 16, σ = 2 | Survey data |
| Storage time before processing (h) | | | |
| Worst | Triangle(a,b,c) | a = 72, b = 168, c = 336 | Survey data |
| Median | Triangle(a,b,c) | a = 18, b = 24, c = 48 | Survey data |
| Best | Triangle(a,b,c) | a = 1, b = 4, c = 10 | Survey data |
| Cooling rate constant ($h^{-1}$) | Pert(a, b, c) | a = 0.0528, b = 0.08, c = 0.1072 | USDA-FSIS (1997) |
| Temperature addition at processing (°C) | Normal(μ, σ) | μ = 5.6, σ = 0.56 | USDA-FSIS (1997) |
| Temperature at processing (°C) | Normal(μ, σ) | μ = 20, σ = 2.5 | Survey data |
| Time for processing (h) | LogNormal(μ, σ) | μ = 1, σ = 1 | Survey data |
| Cooling rate constant ($h^{-1}$) | Pert(a, b, c) | a = 0.33, b = 0.5, c = 0.67 | USDA-FSIS (1997) |
| Storage temperature after processing (°C) | Normal(μ, σ) | μ = 16, σ = 2 | Survey data |
| Storage time after processing (h) | Triangle(a,b,c) | a = 24, b = 48, c = 72 | Survey data |
| Cooling rate constant ($h^{-1}$) | Pert(a, b, c) | a = 0.0053, b = 0.008, c = 0.0107 | USDA-FSIS (1997) |
| | | | |
| **Transportation to retail** | | | |
| Time for transportation (h) | LogNormal(μ, σ) | μ = 3, σ = 3 | Survey data |
| Cooling rate constant ($h^{-1}$) | Pert(a, b, c) | a = 0.066, b = 0.1, c = 0.134 | USDA-FSIS (1997) |
| | | | |
| **Retail storage** | | | |
| Retail storage temperature (°C) | constant | 4, 16, 22 or 30 | |
| Cooling rate constant ($h^{-1}$) | Pert(a, b, c) | a = 0.066, b = 0.1, c = 0.0134 | USDA-FSIS (1997) |
| | | | |

| **Preparation and Consumption** | | | |
|---|---|---|---|
| Log reductions during preparation and cooking | | | |
| Cooked foods | constant | 0 | Expert opinion |
| Lightly cooked foods | Normal($\mu$, $\sigma$) | $\mu = 2$, $\sigma = 0.5$ | Humphrey *et al*. (1989), Bates *et al*. (1995) and expert opinion |
| Well cooked foods | Normal($\mu$, $\sigma$) | $\mu = 12$, $\sigma = 1$ | Humphrey *et al*. (1989), Bates *et al*. (1995) and expert opinion |
| | | | |
| **Dose response** | | | |
| $\log_{10} \alpha$ | Normal($\mu$, $\sigma$) | $\mu = 1.727$, $\sigma = 0.227$ | Chapter 3 |
| $\log_{10} \beta$ | Normal($\mu$, $\sigma$) | $\mu = -0.871$, $\sigma = 0.089$ | Chapter 3 |
| Correlation coefficient, $\rho$ | constant | 0.892 | Chapter 3 |
| | | | |

a = minimum value, b = most likely value, c = maximum value, $\mu$ = mean value, $\sigma$ = standard deviation

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