

Risk Assessment Studies

Report No.16

**SALMONELLA
IN
EGGS AND EGG PRODUCTS**

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Abstract

Salmonellosis is a leading foodborne disease worldwide. Among all the serotypes of the *Salmonella* spp., *Salmonella* Enteritidis is most commonly reported to be involved in human salmonellosis. According to the data provided by the Department of Health (DH), *Salmonella* Enteritidis was the commonest serotype isolated in stool samples in patients during the years of 1997 to 2001. Such serotype is known to have unusual ability to colonize ovarian tissues of hens and be present within the contents of intact shell eggs. According to the figures provided by the DH, 252 confirmed *Salmonella* food poisoning outbreaks (affecting 1628 persons) occurred during 1998 to 2002. Egg and egg products (including desserts) were identified as the incriminated food in 90 (36%) out of 252 cases, involving 415 persons. Further analysis revealed that 55 (61%) out of 90 of these cases were caused by consumption of desserts. Among the 55 cases, tiramisu and pudding were identified as incriminated food items in 21 and 25 outbreaks respectively. Tiramisu and pudding are non-heat-treated type desserts which may contain raw egg ingredients and are prepared without involving any pathogen reduction steps, like heat treatment. The major contributing factors of these cases include the consumption of raw food (eggs) and poor personal hygiene of food handler. Therefore, it would be prudent for the caterers and manufacturers to avoid using raw unpasteurized eggs in preparing desserts and that good hygienic practices should always be adhered for the production of egg and egg products including desserts.

Salmonella in Eggs and Egg Products

OBJECTIVE

The aim of this paper is to evaluate the local situation of salmonella in eggs and egg products, with a focus on desserts containing egg-based ingredients.

INTRODUCTION

2. Eggs and egg products are nutritious foods and they form an important part of the human diet. Consuming eggs, however, has been associated with negative health impacts. Eggs and egg products that are improperly handled can be a source of foodborne diseases, such as salmonellosis.

3. Salmonellosis is a leading foodborne disease worldwide. A wide range of foods has been implicated in such disease. However, foods of animal origin, especially poultry and poultry products, including eggs, have been consistently implicated in sporadic cases and outbreaks of human salmonellosis.¹

Salmonella Species

4. Salmonella is a general name used for a group of more than 2000 closely related bacteria that cause illness by reproducing in the digestive tract. Each Salmonella serotype shares common antigens and has its own name.

5. *Salmonella* Enteritidis (anti-serum group D) and *Salmonella* ser. Typhimurium (anti-serum group B) are the most commonly reported serotypes involving in human salmonellosis. According to the data provided by the Department of Health (DH), *Salmonella* Enteritidis was the commonest serotype isolated from human clinical specimens, followed by *Salmonella* Typhimurium and *Salmonella* Derby during the years of 1997 to 2001. **Table 1** listed the distribution of the most frequently reported Salmonella serotypes in 2000 and 2001.

Table 1: Distribution of the Most Frequently Reported Salmonella Serotypes in 2000 and 2001

Year	Most frequently reported serotypes (% of total)
2000	<i>Salmonella</i> Enteritidis (17.0%) <i>Salmonella</i> Typhimurium (9.3%) <i>Salmonella</i> Derby (8.6%) <i>Salmonella</i> Infantis (2.5%) <i>Salmonella</i> Stanley (2.2%) <i>Salmonella</i> Typhi (2.2%)
2001	<i>Salmonella</i> Enteritidis (25.4%) <i>Salmonella</i> Typhimurium (12.1%) <i>Salmonella</i> Derby (6.1%) <i>Salmonella</i> Muenster (4.7%) <i>Salmonella</i> Rissen (3.9%)

6. Generally speaking, the infectious dose, incubation period, symptoms and mode of transmission of salmonellosis caused by different serotypes are similar. Symptoms include diarrhoea, fever and abdominal cramps with incubation period ranges from 12 to 72 hours. The illness usually last 4 to 7 days and most people recover without treatment. The elderly, infants and those with impaired immune systems are more likely to have a severe illness.²

7. Some specific serotypes like *Salmonella* Typhi and *Salmonella* Paratyphi are also foodborne pathogens causing a systemic illness called typhoid fever and paratyphoid fever respectively. Their spread is predominantly by food and water contaminated by faeces of patients and carriers.

8. *Salmonella* is a rod-shaped, motile, aerobic and facultatively anaerobic, non-spore forming and Gram-negative organism. It can grow from 5°C up to 47°C with an optimum at 37°C. *Salmonella* is heat sensitive and can be readily destroyed at pasteurization temperature.³

9. The infectious dose is usually greater than 10^2 to 10^3 organisms and may vary with age and health status of the host. In some cases, it can be as few as 15 to 20 cells.⁴

10. *Salmonellae* reside in the intestinal tract and are shed in the faeces of infected animals and humans as well. Many foods, particularly those of animal origin and those subject to sewage pollution, have been identified as vehicles for transmitting these pathogens.⁵

Salmonella and Eggs

11. Poultry is widely acknowledged to be a reservoir for *Salmonella*. Egg contents may be contaminated with salmonellae by 2 routes: transovarian (vertical transmission) or trans-shell (horizontal transmission).⁶

12. In vertical transmission, *Salmonella* are introduced from infected reproductive tissues to eggs prior to shell formation. *Salmonella* serotypes associated with poultry reproductive tissues that are of public health concern include *Salmonella* Enteritidis, *Salmonella* Typhimurium and *Salmonella* Heidelberg.^{7,8} Among the different serotypes, *Salmonella* Enteritidis may be better able to achieve invasion, and as a consequence, may be found more frequently in reproductive tissues.⁷

13. Horizontal transmission is usually derived from faecal contamination on the egg shell. It also includes contamination through environmental vectors, such as farmers, pets and rodents. Many different serotypes of the genus *Salmonella* can be involved. They may be able to contaminate egg contents by migration through the egg shell and membranes. Such a route is facilitated by moist egg shells, storage at ambient temperature and shell damage.⁷

14. A survey of eggs destined to British retail markets indicated that *Salmonella* Enteritidis contamination ranged from 0.04 to 0.11%, with the overall contamination for all salmonellae as 0.15 to 0.27%.⁸ In

another study, it was revealed that the overall contamination rate for eggs in total was about 1 in 600 (0.17%), but only 1 in 6,000 for egg contents (0.017%).⁷

15. Investigations in a number of countries have revealed that, when fresh, positive eggs contain about <50 *Salmonella* Enteritidis per egg. Growth in egg contents can occur as a result of storage related changes and become rapid once *Salmonella* can gain access to the egg yolk.⁷

LOCAL FOOD POISONING FIGURES

16. According to the figures provided by the DH, 252 confirmed *Salmonella* food poisoning outbreaks (affecting 1628 persons) occurred during 1998 to 2002. **Table 2** showed the breakdown of these cases by food group.

Table 2: Salmonella Food Poisoning by Food Group (1998 to 2002)

Food Group	Number of confirmed case (%)	Number of persons affected (%)
<i>Egg and egg products (including desserts)</i>	90 (36%)	415 (25%)
Meat, meat products and offals	48 (19%)	191 (12%)
Seafood	33 (13%)	203 (12%)
Poultry, game and their products	31 (12%)	236 (15%)
Others	40 (16%)	548 (34%)
Unknown	10 (4%)	35 (2%)
Total	252 (100%)	1628 (100%)

17. Egg and egg products are important cause of *Salmonella* food

poisoning outbreak, which accounted for 36% of the total number of confirmed cases. **Table 3** summarized the food items under the food group of “egg and egg products (including desserts)”.

Table 3: Salmonella Food Poisoning Outbreaks Due to Consumption of Egg and Egg Products Including Desserts (1998 to 2002)

Food group	Food type	Number of confirmed case (%)*	Number of persons affected (%)*
Egg and egg products (excluding desserts)	Egg (unspecified)	8 (9%)	30 (7%)
	Raw egg	7 (8%)	25 (6%)
	Cooked egg	5 (6%)	15 (4%)
	Mixed dish with egg	5 (6%)	27 (7%)
	Omelette	4 (4%)	9 (2%)
	Rice dish with egg	3 (3%)	15 (4%)
	Sandwiches with egg	3 (3%)	7 (2%)
	Subtotal	35 (39%)	128 (31%)
Desserts	Pudding	25 (28%)	143 (34%)
	Tiramisu	21 (23%)	87 (21%)
	Cheesecakes	4 (4%)	21 (5%)
	Miscellaneous dessert	4 (4%)	23 (6%)
	Other cakes	1 (1%)	13 (3%)
	Subtotal	55 (61%)	287 (69%)
Total		90 (100%)	415 (100%)

* Percentages may not add up to 100% due to rounding of figures

EGG-BASED DESSERTS AS AN EXAMPLE TO ILLUSTRATE THE RISK OF SALMONELLOSIS

18. Since desserts are one of the major incriminated food types causing salmonella food poisoning outbreaks, the rest of the paper will study their risk in relation to salmonellosis.

19. Desserts include any sweet dish that is traditionally eaten after a meal. These foods have gained popularity in recent years that they are now consumed at any time as a separate item. As raw eggs are often used as ingredients for desserts, specific pathogens associated with raw eggs such as salmonellae may be introduced to the food and pose a health risk to consumers, especially for products containing egg-based ingredients that have not been subject to any pathogen reduction steps, like heat treatment. Examples of these non-heat-treated desserts include unbaked cheesecakes (including tiramisu), pudding, mousse, custard, etc..

Functional Properties of Eggs

20. The functions of eggs as a food are of two-fold. Where eggs and egg products provide good source of nutrients, they also provide many desirable attributes as food ingredients.

21. In relation to the production of desserts, several functional properties of eggs and egg products are important – binding, foaming, thickening, colour and flavour contribution and mouthfeel improvement.

22. Whipping of eggs result in coagulation of egg protein and thus bind ingredients together. The whipping action on egg white incorporates air and creates foam which contributes to the lightness of certain products such as mousse. Xanthophyll pigments in egg yolk contribute yellow colour to desserts such as tiramisu and custard. Eggs also impart desirable egg flavour and provide substantial body and smoothness to desserts such

as pudding.

Production Processes

23. The production of non-heat-treated desserts includes steps in the purchase of raw materials, preparation, storage, transportation and service or sale. The general production is illustrated in the flowchart at **Annex I**.

24. While individual recipe may vary and therefore the choice of raw materials may not be the same, common ingredients of desserts are eggs (either as whole egg, egg yolk or egg white), cream, milk, sugar, and gelatin. These products are usually commercially available and are ready-to-use. To produce specific flavoured items, fresh fruits or puree, chocolate, flavouring agents and/or colouring matters may be incorporated.

25. For non-heat-treated type desserts, the preparation step usually involves mixing or folding of ingredients only. The ingredient mixture is then poured into containers and stored under chilling temperature for setting. The product may then be decorated by assorted fruits, chocolate or icing subject to consumers' preference.

26. Desserts sold at bakery chain stores are usually supplied by their own central food factories. These food factories may also supply desserts to other retail outlets. Some restaurants may produce desserts by themselves and serve their customers on the premises.

Contributing Factors Leading to Food Poisoning

27. As mentioned in Table 3, there were 55 confirmed salmonella food poisoning outbreaks due to consumption of desserts during 1998 to 2002. These cases were analyzed and the following table (**Table 4**) listed out the contributing factors of the cases.

Table 4: Contributing Factors of Salmonella Food Poisoning Outbreaks Due to Consumption of Desserts (1998 to 2002)

Contributing factor	No. of confirmed case (% of total)*
Contaminated raw food / raw food consumed	50 (90%)
Poor personal hygiene of food handler	11 (20%)
Improper holding temperature	7 (13%)
Food prepared too far in advance	4 (7%)
Contaminated processed food	3 (6%)
Inadequate cooking	2 (4%)
Unknown	2 (4%)

* There may be more than one contributing factors in one case.

DISCUSSION

28. Serotyping of Salmonella isolates showed that *Salmonella* Enteritidis was the commonest serotype (**Table 1**). Such serotype is known to have unusual ability to colonize ovarian tissues of hens and be present within the contents of intact shell eggs.⁶ It is therefore not surprising that the egg and egg products (including desserts) constituted the highest percentage (36%) of incriminated food items involved in salmonellosis outbreaks.

29. While eggs are usually incorporated as ingredients for making desserts, desserts can also be broadly classified as egg products. Within this group, 55 out of 90 (61%) were desserts that might contain egg-based ingredients. Among the 55 cases, tiramisu and pudding were identified as incriminated food items in 21 and 25 outbreaks respectively.

30. Raw egg shell and its contents are known to be a source of Salmonella. Analysis of the 55 salmonella food poisoning cases (**Table 4**) showed that the major contributing factor of the outbreaks involved contaminated raw food (eggs). It is also possible that the organisms present on egg shells may contaminate egg contents at breaking. Food poisoning risks may then be multiplied where eggs contaminated with (perhaps only a few) salmonellae are bulked with other eggs in catering. Such risk may further be increased in foods containing egg-based ingredients that have not been subject to heat treatment steps to reduce any pathogen that may be present. Therefore, it would be prudent for the caterers and manufacturers to avoid using raw unpasteurized eggs in preparing desserts.

31. It is also revealed from **Table 4** that the second important contributing factor to Salmonella food poisoning outbreak related to poor personal hygiene of food handlers. Good hygienic practices should always be adhered. Avoiding cross-contamination from contaminated egg shell or ingredients is also very important. This is especially important in restaurant settings where raw unpasteurized eggs may be frequently used as ingredients for preparation of other food products. It is vital that all food preparation areas are kept clean and regularly sanitized in order to reduce

the risks of food poisoning outbreaks.

CONCLUSION AND RECOMMENDATIONS

32. To minimize the potential risk of salmonellosis due to the consumption of egg and egg products, good manufacturing and handling practices should always be observed. Reference can be made to a World Health Organization (WHO) educational brochure which outlines the safe procedure for consumers as well as food handlers to follow when handling and preparing eggs and food containing eggs.⁹ The followings are some recommendations:

Advice to Trade

(A) Handling of raw materials:

1. Purchase raw materials from reputable and reliable suppliers.
2. Choose pasteurized eggs products or dried egg powder to prepare dishes, in particular ready-to-eat desserts.
3. Eggs stained with dirt should be washed. Washed eggs should then be used as soon as possible.
4. Avoid using cracked eggs as they are more likely to be contaminated and thus present a higher health risk.
5. Adopt a first-in-first-out principle to store raw materials and keep them at appropriate temperatures.
6. Observe “best before” date and avoid using expired materials.
7. Avoid holding chilled ingredients and finished products at above 4°C for more than 2 hours.

(B) Manufacturing and storage

1. Store shell eggs under refrigeration.
2. Cook eggs until all parts reach a minimum temperature of 70°C and both the yolk and the white are firm. Scrambled and fried eggs need to be cooked in small batches until they are firm (not runny throughout). Boiled eggs, depending on their initial size and temperature, may require a minimum boiling period of 7 to 9 minutes to ensure that the yolk becomes firm.
3. Avoid preparing ready-to-eat dishes and raw foods at the same time.
4. Avoid preparing dishes in large quantities at one time and too far in advance.
5. Store and transport desserts intended to be served cold at 4°C or below.
6. Display desserts to be served cold for sale in a proper manner and at 4°C or below.

(C) Equipment, utensil and personal hygiene

1. Establish a clean-up and disinfection programme to clean and sterilize equipment and utensils including refrigerators, chopping boards, choppers, containers and mixers.
2. Observe good personal hygiene. Food handlers should wash their hands with soap and potable water thoroughly before preparing food and after every interruption in food preparation, particularly after having used the toilet.
3. Prevent cross-contamination between raw eggs and other food.

Advice to Public

(A) Purchase

1. Buy food from reputable and reliable suppliers.
2. Check the “best before” date and pay attention to the storage temperature of pre-packaged eggs.

(B) Homemade desserts

1. Avoid using recipes that call for raw unpasteurized eggs as ingredients.

(C) Consumption of desserts

1. Consume desserts as soon as possible.
2. If desserts are not consumed immediately, they (including homemade ones) should be:
 - packed and stored at 4°C or below.
 - separated from raw food.
 - consumed within 1 to 2 days.
3. The elderly, children, pregnant women and persons with lowered immunity should be careful when choosing food especially high risk food, such as unbaked cheesecake (including tiramisu), pudding, mousse and custard.

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General Production Flowchart of Desserts

