Salmonella in Seafoods

T. S. G. IYER

Among Gram-negative rod-shaped bacteria causing food-borne gastroenteritis, the most important are members of the genus *Salmonella*. 'Salmonella' is the generic name applied to a group of bacteria which was formerly known as 'paratyphoid bacteria' derived by D.E. Salmon in 1885. Salmonellae are enteric organisms belonging to the family 'Enterobacteriaceae'.

Morphology

Salmonellae are Gram-negative, rod shaped bacteria mostly motile with the exception of *S. pullorum* and *S. gallinarum*. They do not form spores.

Clinically distinguishable forms

Three clinically distinguishable forms of *Salmonella* are available.

1. Those producing enteric fevers
   a) Typhoid fever : *S. typhi*
   b) Para typhoid fever : *S. paratyphi* A, B and C.
2. Those producing septicaemia. This usually happens when the organism gets into the blood stream
   eg: *S. cholerae - suis.*
3. Those producing gastroenteritis. All except *S. typhi* and *S. paratyphi* produce gastroenteritis. Usually, this happens on ingestion of food contaminated with *Salmonella.*

Primary habitat

The primary habitat of *Salmonella* is the gut of infected man and animals, especially warm blooded animals, mammals, birds, insects, lizards,

rodents and snakes. From the gut, it is excreted out through faeces and hence found in sewage. Some people will be carriers of *Salmonella.*

Conditions for onset of symptoms

Ingestion of *Salmonella* by man or animals does not often result in sickness. In certain cases, these men or animals may become carriers without exhibiting symptoms of the disease. The number of cells required to trigger off food-borne illness depends upon the *Salmonella* serotype in question, the conditions and age of the person consuming the food and whether or not the contaminated food is ingested on an empty stomach. Infants, the elderly, the under-nourished and debilitated are known to be more susceptible to the disease and in such persons Salmonellosis is known to occur on ingestion of even one cell per gram.

Symptoms

Salmonella food poisoning symptoms are presumed to be due to the liberation of endotoxin from the cells by the action of the low pH in the stomach. The onset of symptoms is usually within 12-24 hours after consuming the infected food. The usual symptoms are nausea, vomiting, abdominal pain, headache, diarrhoea and fever accompanied by prostration, muscular pain, restlesness and drowsiness which last for 2 to 3 days.

In the case of *Salmonella* species that produce enteric fever, the symptoms are more severe. Infection is by ingestion of the organism which pass from the small intestine to the mesentericus and after a period of multiplication, they invade the blood stream and then come back to the gut. Liver, gall bladder, spleen, kidneys and bone morrow are affected. Fever, diarrhoea, restlesness, weakness, abdominal pain and severe headache are the usual symptoms. Complete recovery is possible only in about 20 days. At this stage, while these organisms generally disappear from the intestinal tract of most of the patients, upto 5% of the victims may become carriers of the organism for about 3 to 4 months. In fact, "carriers" are known to be the main source of *Salmonella* contamination in many types of food materials.

Incidence of *Salmonella* in seafoods

Fresh fish collected from the open sea is free from *Salmonella*. However, fish from polluted coastal waters are usually infected with *Salmonella*.

There are several reports on the incidence of *Salmonella* in freshwater fishes collected from the river Nile, river Plate, Polish rivers and lakes of Central Africa. There are reports from the Western Countries on the isolation of *Salmonella* from eel, tuna, smoked fish, mussels, raw shrimps, cooked shrimps, picked crab meat, cat fish, fish meal and froglegs. Salmonellosis on consumption of fish cakes, raw oysters, canned salmon, smoked white fish and whale blubber has also been reported.

The Central Institute of Fisheries Technology, Cochin has made the following observations (Table 1) on the incidence of *Salmonella* in seafoods and processing environments.

Table 1. *Incidence of* Salmonella *in seafoods and processing environments*

No.	Sample		Number of samples analysed	% sample showing incidence of *Salmonella*
1	HL shrimps	frozen	130	10
2	PD shrimps	"	150	12
3	PUD shrimps	"	100	14
4	Cooked shrimps	"	180	0
5	Rock lobster tails	"	70	0
6	Sand lobster tails	"	66	3.3
7	Cooked lobsters	"	65	1.6
8	Cuttle fish	"	50	14
9	Squid	"	30	2
10	Cat fish	"	40	25

(Table 1 Continued)

11	Seer fish	40	20
12	Fresh fish	360	4
13	Dried non-penaeid prawn	25	4
14	Fish meal	80	1.2
15	Fried fish, fish curry, cutlets	200	0
16	Sea beach sand	22	23
17	Fish contact surfaces	150	2
18	Floor	50	4
19	Water	120	1
20	Ice	120	1

Sources of contamination

CIFT has carried out detailed studies on the sources of *Salmonella* in the seafood processing line. The following (Table 2) are the major sources.

Table 2. *Sources for* Salmonella *in the seafood processing line*

No.	Source	Serotype isolated
1	Coastal sea water	*S. havana*
2	Water from culture pond	*S. farmsen* *S. weltevreden*
3	Mud from culture pond	*S. newport*
4	Sea beach sand	*S. weltevreden* *S. bareilly*
5	Process water	*S. typhimurium*
6	Ice	*S. bareilly*
7	Floor	*S. bareilly* *S. weltevreden*
8	Utensils	*S. weltevreden*
9	Droppings of wall lizards seen on processing tables	*S. weltevreden*

(Table 2 Continued)

10	Droppings of rodents seen on processing tables	*S. weltevreden* *S. typhimurium*
11	Table tops known to have been contaminated with rodent droppings	*S. typhimurium* *S. weltevreden*

Salmonella serotypes

More than 2000 serotypes of *Salmonella* are known to exist. But, all the serotypes need not be present in one country. According to the Joint FAO/WHO Expert Committee on Microbiological Aspects of Food Hygiene (1968), only 100 serotypes are observed regularly. Different serotypes dominate in different parts of the world (Table 3) but it seems that *S. typhimurium* is the serotype most frequently encountered. The pattern can change drastically in any country within a short period. Thus in 1971, the U.S. and several countries experienced a sudden increase in the frequency of isolation of *S. agona* whereas *S. wein* increased in France. In all these cases, the probable cause of increase of certain specific serotypes is due to the international movement of people, food and feed.

Table 3. *Dominant serotypes in different parts of the world*

	Serotype	Country
1.	*S. orion*	Australia
2.	*S. heidelberg*	Bulgaria
3.	*S. worthington*	Thailand
4.	*S. abony*	Yugoslavia
5.	*S. virchow*	Burma
6.	*S. wein*	France
7.	*S. weltevreden*	Southern Asia
8.	*S. tyhi*	Countries of the Mediterranean region
9.	*S. typhimurium*	India

Some *Salmonella* serotypes are known to have certain host specificity. For example, *S. gallinarum* is seen in chicken, *S. cholerae-suis* in pigs, *S. weltevreden* in wall lizards and *S. enteritidis* in rodents, cows, sheep and goat.

In India, about 180 serotypes have so far been isolated from various sources like man, animals, clinical specimens, water and food products. Till recently, no detailed study had been carried out on the *Salmonella* pattern in fishery products. Detailed studies carried out at CIFT have resulted in the isolation of about 46 different serotypes of *Salmonella* which constitute about 25% of the total serotypes isolated on a National level from various sources. The *Salmonella* pattern in fish and fishery products and processing environments is given in Table 4.

Table 4. Salmonella *pattern in marine products and processing environments*

Number of strains isolated from

Serotype	Frozen froglegs	Frozen shrimps	Fresh shrimps	Frozen fish	Fresh fish	Frozen lobsters	Fresh lobsters	Frozen squid	Frozen cuttlefish	Water	Ice	Other sources
S. typhimurium	26(15.7)	–	1(7.7)	3(10)	–	1(5.0)	2(12.5)	12(57.2)	–	1(7.1)	-	3[a](4.1)
S. arizonae	20(12.1)	–	–	2(6.6)	–	–	–	–	–	–	–	–
S. roan	18(11.0)	2(2.6)	–	–	–	–	–	–	–	–	–	6[b](8.2)
S. saintpaul	12(7.2)	2(2.6)	1(7.7)	–	–	–	–	–	–	–	–	2[c](2.7)
S. bareilly 16[n](21.9)	11(6.6)	5(6.2)	–	3(10)	2(4)	–	–	5(23.8)	–	6(42.9)	8(100)	
S. newport	11(6.6)	–	–	–	–	–	–	–	–	–	–	8[m](11.0)
S. anatum	10(6.1)	–	–	–	–	–	–	–	–	–	–	–
S. bredeney	6(3.6)	–	–	–	–	–	–	–	–	–	–	–
S. matopeni	6(3.6)	–	–	–	–	–	–	–	–	–	–	–
S. chester	5(3.1)	–	–	–	–	–	–	–	–	–	–	–

(Table 4 continued)

S. nchanga	5(3.1)	–	–	–	–	1(5.0)	–	–	–	–	–	–
S. chingola	5(3.1)	–	–	–	–	–	–	–	–	–	–	–
S. hvittingfoss	5(3.1)	1(1.3)	–	–	–	–	–	–	–	–	–	1[b](1.4)
S. heidelberg	5(3.1)	–	1(7.7)	–	–	–	–	–	–	–	–	–
S. waycross	4(2.4)	–	–	–	–	–	–	–	–	–	–	–
S. stanley	3(1.8)	–	–	–	3(6)	–	–	–	–	–	–	–
S. richmond	3(1.8)	1(1.3)	–	–	–	–	–	–	–	–	–	1[d](1.4)
S. salford	3(1.8)	–	–	–	–	–	–	–	–	–	–	–
S. virchow	2(1.2)	1(1.3)	2(15.4)	–	6(12)	–	–	–	–	–	–	–
S. larochelle	2(1.2)	–	–	–	3(6)	–	–	–	–	–	–	–
S. cubana	1(0.6)	–	–	–	–	–	–	–	–	–	–	–
S. senftenberg	–	–	–	–	–	3(15.0)	–	2(9.5)	–	–	–	–
S. orion	–	1(1.3)	–	1(3.4)	–	–	–	–	–	–	–	–
S. weltevreden	–	41(51.0)	3(23.0)	20(66.6)	16(32)	15(75.0)	14(87.5)	2(9.5)	–	4(28.7)	–	15[e](20.5)
S. poona	–	–	1(7.7)	1(3.4)	–	–	–	–	–	–	–	–
S. paratyphi B	–	–	–	–	–	–	–	–	–	–	–	7[f](9.6)
S. ohio	–	–	–	–	2(4)	–	–	–	–	–	–	–
S. muenchen	–	–	–	–	4(8)	–	–	–	–	–	–	–
S. alachua	–	–	–	–	4(8)	–	–	–	–	–	–	–
S. eastbourne	–	–	–	–	2(4)	–	–	–	–	–	–	–
S. oranienberg	–	–	–	–	7(14)	–	–	–	–	–	–	–
S. subgenus III	–	–	–	–	1(2)	–	–	–	–	–	–	–
S. enteritidis	–	–	–	–	–	–	–	–	–	–	–	7[g](9.6)

(Table 4 continued)

S. agona	–	–	–	–	–	–	–	–	–	–	–	3[j](4.1)
S. urbana	–	–	1(7.7)	–	–	–	–	–	–	–	–	2[j](2.7)
S. branderup	–	–	–	–	–	–	–	–	–	–	–	1[k](1.4)
S. falkensee	–	–	–	–	–	–	–	–	–	–	–	1[l](1.4)
S. wentworth	–	14(17.4)	–	–	–	–	–	–	–	–	–	–
S. cerra	–	1(1.3)	2(15.4)	–	–	–	–	–	–	–	–	–
S. gaminara	–	1(1.3)	–	–	–	–	–	–	–	–	–	–
S. rubislow	–	1(1.3)	–	–	–	–	–	–	–	–	–	–
S. mgulani	–	9(11.1)	–	–	–	–	–	–	–	–	–	–
S. augustenberg	–	–	1(7.7)	–	–	–	–	–	–	–	–	–
S. oslo	–	–	–	–	–	–	–	–	8(100.0)	–	–	–
S. havana	–	–	–	–	–	–	–	–	–	1(7.1)	–	–
S. farmsen	–	–	–	–	–	–	–	–	–	2(14.2)	–	–

3[a] One strain from floor and 2 strains from table top.
6[b] All strains from fresh froglegs.
3[c] Both the strains from fresh froglegs.
1[d] From fresh froglegs.
15[e] One strain from floor, 3 strains from utensils, 4 strains from sea beach sand, one strain from dried clams and six strains from frozen crab meat.
7[f] Five strains from fresh froglegs, one from fish meal and one from poultry feed.
7[g] All strains from dried jawala prawns.
1[h] From dried clams.
3[i] From frozen boiled clams.
2[j] From fresh clam meat.
1[k] From fresh mussel meat.
1[l] From fish meal.
8[m] All from mud from shrimp culture pond.
16[n] Six from poultry feed, 3 from floor and 7 from sea beach sand.

Figures in parenthesis indicate percentage.

The dominating serotype in various fishery products is as follows (Table 5).

Table 5. *Dominating serotypes in various fishery products*

Sample	Dominating serotype
Frozen froglegs	*S. typhimurium*
Frozen shrimps	*S. weltevreden*
Fresh fish	*S. weltevreden*
Frozen fish	*S. weltevreden*

CIFT, Cochin isolated the following serotypes of *Salmonella* for the first time in India (Table 6).

Table 6. *Serotypes isolated for the first time in India*

No.	Serotype	Date of isolation	Source
1.	*S. roan*	19.10.77	Frozen froglegs (Cochin)
2.	*S. larochelle*	27.11.79	Frozen froglegs (Bombay)
3.	*S. wentworth*	25.2.86	Frozen sand lobsters (Cochin)
4.	*S. farmsen*	2.7.87	Water from culture pond (Cochin)
5.	*S. mgulani*	2.7.88	Frozen shrimps (Madras)

The studies also resulted in the isolation of certain rare serotypes of Salmonella (Table 7).

Table 7. *Rare serotypes of Salmonella isolated from fishery products*

No.	Serotype	Date of isolation	Source of isolation	Place
1.	*S. heidelberg*	12.7.76	Fish / shrimps	Cochin
2.	*S. matopeni*	7.11.77	Frozen froglegs	Cochin
3.	*S. waycross*	7.11.77	Frozen froglegs	Cochin
4.	*S. chingola*	13.10.77	Frozen froglegs	Cochin
5.	*S. eastbourne*	2.2.82	Fresh tuna fillet	Bombay
6.	*S. orion*	5.6.79	Frozen red snapper	Bombay
7.	*S. braenderup*	25.3.86	Fresh mussel meat	Calicut

Standards pertaining to the presence of *Salmonella*

The organism should be totally absent in seafoods. It is generally accepted that presence of any serotype of *Salmonella* at any level in a food material has to be regarded as a potential hazard.

Viability during freezing and frozen storage

The following observations (Table 8) have been made in the studies carried out at CIFT:

1. All serotypes of *Salmonella* can survive freezing at -40°C.
2. During frozen storage (-20°C), *Salmonella* can survive upto 9 months depending upon the serotype and the initial bacterial load

Table 8. *Viability of* Salmonella *during freezing and frozen storage*

No.	Serotype	Before freezing	After freezing	Viability after .... months 1	2	3	4	5	6	7	8	9	10
1	*S. typhimurium*	+	+	+	+	+	+	+	+	+	+	–	–
2.	*S. paratyphi B*	+	+	+	+	+	+	+	+	+	+	+	–
3.	*S. newport*	+	+	+	+	+	+	+	+	+	+	–	–

(Table 8 Continued)

4.	*S. weltevreden*	+	+	+	+	+	+	+	+	–	–	–	–
5.	*S. roan*	+	+	+	+	+	+	+	+	+	+	–	–
6.	*S. poona*	+	+	+	+	+	+	+	+	+	+	–	–
7.	*S. saintpaul*	+	+	+	+	+	+	–	–	–	–	–	
8.	*S. salford*	+	+	+	+	+	+	+	+	+	+	–	–

+ = Viable – = Not viable

Prevention of contamination

1. Avoid fishing from polluted water.
2. Avoid washing with near-shore waters.
3. Avoid sorting the catch on sea beaches.
4. Use only chlorinated water (10 ppm) for processing and for ice manufacture.
5. Workers may be periodically examined to detect carriers.
6. Those who are suffering from vomiting or diarrhoea should keep away from work.
7. Before starting work, all fish handlers may wash and disinfect their hands.
8. Entry of rodents, wall lizards and flies to the processing hall may be avoided.
9. Before starting and after finishing each day's work, all the utensils used for processing may be cleaned and disinfected.