

Chapter 17: *Salmonella*

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Potential Food Safety Hazard

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Salmonella is a rod-shaped, motile bacterium -nonmotile exceptions *S. gallinarum* and *S. pullorum*-, nonsporeforming and Gram-negative. There is a widespread occurrence in animals, especially in poultry and swine. Environmental sources of the organism include water, soil, insects, factory surfaces, kitchen surfaces, animal feces, raw meats, raw poultry, and raw seafoods, to name only a few.

S.typhi and the paratyphoid bacteria normally cause septicemia and produce typhoid or typhoid-like fever in humans. Other forms of salmonellosis generally produce milder symptoms.

Acute symptoms include nausea, vomiting, abdominal cramps, diarrhea, fever, and headache. Chronic consequences include arthritic symptoms that may follow 3 - 4 weeks after onset of acute symptoms. Onset of the illness is usually 6 - 48 h. The infective dose is as few as 15–20 cells; depends upon age and health of host, and strain differences among the members of the genus. Acute symptoms may last for 1 to 2 d or may be prolonged, again depending on host factors, ingested dose, and strain characteristics.

The disease is caused by penetration and passage of *Salmonella* organisms from gut lumen into epithelium of small intestine where inflammation occurs; there is evidence that an enterotoxin may be produced, perhaps within the enterocyte. Foods commonly associated with the disease include raw meats, poultry, eggs, milk and dairy products, fish, shrimp, frog legs, yeast, coconut, sauces and salad dressing, cake mixes, cream-filled desserts and toppings, dried gelatin, peanut butter, cocoa, and chocolate.

Various *Salmonella* species have long been isolated from the outside of egg shells. The present situation with *S. enteritidis* is complicated by the presence of the organism inside the egg, in the yolk. This and other information strongly suggest vertical transmission, i.e., deposition of the organism in the yolk by an infected layer hen prior to shell deposition. Foods other than eggs have also caused outbreaks of *S. enteritidis* disease (FDA, 1998).

Control Measures

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Hazards from *Salmonella* can be prevented by: heating seafood sufficiently to kill the bacteria (e.g., 24 s at 165°F), holding chilled seafood below 4.4°C (40°F), preventing post-cooking cross-contamination and prohibiting people who are ill or are carriers of *Salmonella* from working in food operations. (Ward et al., 1997).

Guidelines

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ICMSF recommended microbial limits

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Recommended microbiological limits for *Salmonella* in fish (ICMSF, 1986).

Product	n ¹	c ²	Bacteria/gram or cm ²	
			m ³	M ⁴
Fresh and frozen fish and cold-smoked fish	5	0	0	-
Frozen raw crustaceans	5	0	0	-
Frozen cooked crustaceans	10	0	0	-
Fresh and frozen bivalve molluscs	20	0	0	-

¹Number of representative sample units.

² Maximum number of acceptable sample units with bacterial counts between m and M.

³ Maximum recommended bacterial counts for good quality products.

⁴ Maximum recommended bacterial counts for marginally acceptable quality products.

Plate counts below "m" are considered good quality. Plate counts between "m" and "M" are considered marginally acceptable quality, but can be accepted if the number of samples does not exceed "c." Plate counts at or above "M" are considered unacceptable quality (ICMSF, 1986).

[Canadian Food Inspection Agency Bacteriological Guidelines for Fish and Fish Products](#) (CFIA)

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FDA Guidelines

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[Table A-5.](#) FDA guideline for *Salmonella* in fish.

State Guidelines

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State Guidelines for *Salmonella* in seafood.

State	Products	Maximum <i>Salmonella</i>
Alabama	-	-
Alaska	-	-
Arizona	-	-
Arkansas	-	-
California	-	-
Colorado	-	-
Connecticut	-	-
Delaware	-	-
Florida	-	-
Georgia	-	-
Hawaii	-	-
Idaho	-	-
Illinois	-	-
Indiana	-	-
Iowa	-	-
Kansas	-	-
Kentucky	-	-
Louisiana	-	-
Maine	-	-
Maryland	-	-

Massachusetts	-	-
Michigan	-	-
Minnesota	-	-
Mississippi	Oysters, clams, and mussels - fresh and frozen	0
Missouri	-	-
Montana	-	-
Nebraska	Oysters, clams, mussels, fresh or frozen	0
	Deli foods (shrimp salad, etc.)	0
Nevada	-	-
New Hampshire	-	-
New Jersey	"Potentially hazardous" (tuna, shrimp salad)	0
New Mexico	-	-
New York	-	-
North Carolina	-	-
North Dakota	-	-
Ohio	-	-
Oklahoma	-	-
Oregon	-	-
Pennsylvania	-	-
Rhode Island	-	-
South Carolina	-	-
South Dakota	-	-
Tennessee	-	-
Texas	-	-
Utah	-	-
Vermont	-	-
Virginia	-	-
Washington	-	-
West Virginia	-	-
Wisconsin	-	-
Wyoming	-	-

(NFI, 1998)

Growth

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[Table A-1.](#) Limiting conditions for pathogen growth.

Heat Resistance

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Heat resistance of *Salmonella*.

Temp.		D-Value	Medium	Reference
(°C)	(°F)	(min.)		
57.2	135	95	Sucrose soln.	Goepfert et al., 1970
60	140	7.5	0.5% NaCl	Thomas et al., 1966
60	140	10.0	Pea soup	Thomas et al., 1966
60	140	1.5	Egg, pH 8.0	Anellis et al., 1954
60	140	9.5	Egg, pH 5.5	Anellis et al., 1954
65.5	150	1.2	Skim milk	Thomas et al., 1966

Analytical Procedures

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[Food sampling and preparation of sample homogenate](#) (USFDA)

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[Methods for the isolation and identification of *Salmonella* from foods](#) (HC MFHPB-20)

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[Detection of *Salmonella* spp. in food and agricultural products by the Vidas SLM™ method](#) (HC MFLP-24)

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[Detection of *Salmonella* spp. in food and agricultural products by the Gene-Trak® DNA hybridization method](#) (HC MFLP-54)

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[The Qualicon Bax® method for the detection of *Salmonella* in foods and environmental samples](#) (HC MFLP-62)

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[Detection of *Salmonella* in foods by the modified 1-2 test](#) (HC MFLP-70)

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[Procedure for the isolation of *Salmonella* species by the modified semi-solid Rappaport Vassiliadis \(MSRV\) method](#) (HC MFLP-75)

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[The Reveal Test Kit for detecting *Salmonella*](#) (HC MFLP-96)

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Other analytical methods

- Motile and non-motile *Salmonella* in foods: Polyclonal enzyme immunoassay screening method (AOAC, 1995b).
- Motile *Salmonella* in all foods: Immunodiffusion (1-2 Test) method (AOAC, 1995c).
- *Salmonella*, *Escherichia coli*, and other Enterobacteriaceae in foods: Biochemical system identification (Vitek GNI) screening method (AOAC, 1995d).
- *Salmonella* in cocoa and chocolate: Motility enrichment on modified semi-solid Rappaport-Vassiliadis (MSRV) medium (AOAC, 1995e).
- *Salmonella* in dried milk products: Motility enrichment on modified semi-solid Rappaport-Vassiliadis (MSRV) medium (AOAC, 1995f).
- *Salmonella* in dry foods: Refrigerated preenrichment and selective enrichment broth culture methods (AOAC, 1995g).
- *Salmonella* in foods: Automated conductance method (AOAC, 1995h).
- *Salmonella* in foods: Colorimetric deoxyribonucleic acid hybridization method (GENE-TRAK) (AOAC, 1995i).
- *Salmonella* in foods: Colorimetric monoclonal EIA (*Salmonella*-Tek) screening method (AOAC, 1995j).
- *Salmonella* in foods: Colorimetric monoclonal enzyme immunoassay (*Salmonella* Tek) (AOAC, 1995k).
- *Salmonella* in foods: Colorimetric polyclonal enzyme immunoassay screening method (AOAC, 1995l).
- *Salmonella* in foods: Detection (AOAC, 1995m).
- *Salmonella* in foods: DNA hybridization screening method (AOAC, 1995n).
- *Salmonella* in foods: Fluorescent antibody (FA) screening method (AOAC, 1995o).
- *Salmonella* in foods: Fluorogenic and colorimetric monoclonal enzyme immunoassay (Q-Trol) screening methods (AOAC, 1995p).
- *Salmonella* in foods: Hydrophobic grid membrane filter (iso-grid) screening method (AOAC, 1995q).
- *Salmonella* in foods: Identification (AOAC, 1995r).
- *Salmonella* in foods: Preparation of culture media and reagents (AOAC, 1995s).
- *Salmonella* in foods: Serological tests (AOAC, 1995t).
- *Salmonella* in low-moisture foods (AOAC, 1995u).
- *Salmonella* in raw, highly contaminated foods and animal feeds, detection (AOAC, 1995v).
- *Salmonella* spp., *Escherichia coli*, and other enterobacteriaceae in foods: Biochemical identification kit method (AOAC, 1995w).
- *Salmonella* spp. in foods: Biochemical identification kit method (AOAC, 1995x).

Commercial Test Products

Commercial test products for *Salmonella*.

Test Kit	Analytical Technique	Approx. Total Test Time ¹	Supplier
1-2 Test ²	Immunodiffusion	36 h	BioControl Systems, Inc. Contact: Robin Forgey 12822 SE 32nd St. Bellevue, WA 98005 Phone: 800/245-0113; 425/603-1123 E-mail: info@rapidmethods.com Web: www.rapidmethods.com
Assurance Gold Salmonella EIA	Enzyme immunoassay	29.5 h	BioControl Systems, Inc. Contact: Robin Forgey 12822 SE 32nd St. Bellevue, WA 98005 Phone: 800/245-0113; 425/603-1123 E-mail: info@rapidmethods.com Web: www.rapidmethods.com
Assurance Salmonella EIA ²	Enzyme immunoassay	48 h	BioControl Systems, Inc. Contact: Robin Forgey 12822 SE 32nd St. Bellevue, WA 98005 Phone: 800/245-0113; 425/603-1123 E-mail: info@rapidmethods.com Web: www.rapidmethods.com
BAX [®] for Screening/Salmonella ²	Polymerase chain reaction	26-30 h	Qualicon, Inc. P.O. Box 80357 Wilmington, DE 19880-0357 Phone: 800/863-6842; 302/695-9400 E-mail: info@qualicon.com Web: www.qualicon.com
Bind [®] Salmonella ²	Bacteriophage with gene for ice crystal proteins and indicator dye	22 h	IDEXX Laboratories, Inc. Contact: Greg Getchell One Idexx Dr. Westbrook, ME 04092 Phone: 800/321-0207; 207/856-0580 E-mail: greg-getchell@idexx.com Web: www.idexx.com/fed/home/start.asp
Bioline Salmonella OPTIMA for qualitative detection of <i>Salmonella spp</i>	ELISA	42 h	Bioline ApS Fredericiavej 414 DK-7080 Børkop Denmark Phone: +45 76 62 07 09 Fax: +45 76 62 07 05 E-mail: info@bioline.dk Web: www.bioline.dk
Bioline Salmonella	ELISA	26 h	Bioline ApS

SELECTA for qualitative detection of <i>Salmonella</i> spp			Fredericiavej 414 DK-7080 Børkop Denmark Phone: +45 76 62 07 09 Fax: +45 76 62 07 05 E-mail: info@bioline.dk Web: www.bioline.dk
CHECK 3 Salmonella	Chemical, visual detection	4-18 h	Contamination Sciences LLC Contact: Robert Steinhauser 4230 East Towne Blvd., Suite 191 Madison, WI 53704 Phone: 608/825-6125 E-mail: bsteinha@contam-sci.com Web: www.contam-sci.com
CheckPoint Colony Lift Immunoassay Kit for Presumptive Detection of Group D Salmonella	Colony lift immunoassay	15-18 h	Kirkegaard & Perry Laboratories, Inc. Contact: Diagnostic Technical Services 2 Cessna Court Gaithersburg, MD 20879-4174 Phone: 800/638-3167; 301/948-7755 E-mail: diagnostics@kpl.com Web: www.kpl.com
Chromogenic Salmonella [A differentiation test for <i>Salmonella</i> spp. including <i>S. typhi</i>]		72 h	Biomedix Contact: Claver Bundac 1105 #F North Golden Springs Dr. Diamond Bar, CA 91765 Phone: 800/674-8648 #4282; 909/396-0244 E-mail: cb4biomedx@aol.com
Dynabeads [®] anti-Salmonella ²	Immunomagnetic separation	48 or 72 h	Dynal Inc. Contact: Technical Service 5 Delaware Dr. Lake Success, NY 1042 Phone: 516/326-3270 E-mail: techserv@dynalusa.attmail.com Web: www.dynal.no
EIAFoss Salmonella ²	Combination ELISA and immunomagnetic separation	22-24 h	Foss North America, Inc. 7682 Executive Dr. Eden Prairie, MN 55344 Phone: 612/974-9892 E-mail: sales@fossnorthamerica.com Web: www.fossnorthamerica.com
GENE-TRAK Salmonella Assay ²	Nucleic acid hybridization	48 h	Neogen Corporation 620 Leshner Pl. Lansing, MI 48912 Phone: 517/372-9200 E-mail: NeogenCorp@aol.com Web:

			www.neogen.com/genetrakback.htm
ISO-GRID Method for Salmonella Detection using EF-18 Agar ²	Enrichment followed by membrane filtration with selective and differential culture medium based on lysine decarboxylase and sucrose fermentation	42-72 h (42-48 h for negative screen and 24 h additional to confirm presumptive positive result)	Neogen Corporation 620 Leshar Pl. Lansing, MI 48912 Phone: 517/372-9200 E-mail: NeogenCorp@aol.com Web: www.neogen.com/isogridgen.htm
Oxoid Salmonella Latex Test ²	Polyvalent latex agglutination	42 h	Oxoid, Inc. Contact: Jim Bell 217 Colonnade Rd. Nepean, Ontario K2E 7K3 Canada Phone: 613/226-1318 E-mail: jbelle@oxoid.ca
Oxoid Salmonella Rapid Test ²	Rapid differential culture with serological confirmation	42 h	Oxoid, Inc. Contact: Jim Bell 217 Colonnade Rd. Nepean, Ontario K2E 7K3 Canada Phone: 613/226-1318 E-mail: jbelle@oxoid.ca
PATH-STICK One Step Rapid Salmonella Test	Immunochromatography	38 to 56 h	Celsis, Inc. Contact: Susan Moffa 165 Fieldcrest Ave. Edison, NJ 08837 Phone: 800/222-8260; 732-346-5100 E-mail: smoffa@celsis.com Web: www.celsis.com
Probelia PCR System	Polymerase chain reaction	22 h	BioControl Systems, Inc. Contact: Robin Forgey 12822 SE 32nd St. Bellevue, WA 98005 Phone: 800/245-0113; 425/603-1123 E-mail: info@rapidmethods.com Web: www.rapidmethods.com
Reveal [®] Microbial Screening Test for Salmonella ²	Sandwich ELISA	21 h	Neogen Corporation 620 Leshar Pl. Lansing, MI 48912 Phone: 517/372-9200 E-mail: NeogenCorp@aol.com Web: www.neogen.com
Salmonella ²	Culture	48 h	Contamination Sciences LLC Contact: Robert Steinhauer 4230 East Towne Blvd., Suite 191 Madison, WI 53704 Phone: 608/825-6125

			E-mail: bsteinha@contam-sci.com Web: www.contam-sci.com
GENE-TRAK Salmonella DLP ²	Nucleic acid hybridization	48 h	Neogen Corporation 620 Lesher Pl. Lansing, MI 48912 Phone: 517/372-9200 E-mail: NeogenCorp@aol.com Web: www.neogen.com/genetrakback.htm
Salmonella Screen/Salmonella Verify ²	Immunomagnetic separation latex agglutination (for positive samples only)	24 h	Vicam, L.P. Contact: Brian Kraus 313 Pleasant St. Watertown, MA 02472 Phone: 800/338-4381 E-mail: vicam@vicam.com Web: www.vicam.com
Salmonella Screen/SE Verify ²	Immunomagnetic separation latex agglutination (for positive samples only)	24 h	Vicam, L.P. Contact: Brian Kraus 313 Pleasant St. Watertown, MA 02472 Phone: 800/338-4381 E-mail: vicam@vicam.com Web: www.vicam.com
Salmonella-Tek TM 24-Hour Method ²	Bead immunocapture	24 h	Organon Teknika Corp. 100 Akzo Ave. Durham, NC 27712 Phone: 800/654-0331; 919/620-2000 E-mail: casey@orgtek.com
Salmonella-Tek TM 48-Hour Method ²	ELISA	48 h	Organon Teknika Corp. 100 Akzo Ave. Durham, NC 27712 Phone: 800/654-0331; 919/620-2000 E-mail: casey@orgtek.com
TECRA Salmonella Immunocapture	Immunocapture prior to using TECRA SALM VIA	24 h	International BioProducts Contact: Mike Yeager 14780 NE 95th St. Redmond, WA 98052 Phone: 800/729-7611; 425/883-1349 E-mail: myeager@intlbioproducts.com Web: intlbioproducts.com
TECRA Salmonella Unique ²	Immunoenrichment/ELISA	22 h	International BioProducts Contact: Bob Ward 14780 NE 95th St. Redmond, WA 98052 Phone: 800/729-7611; 425/883-1349 E-mail:

			myeager@intlbioproducts.com Web: intlbioproducts.com
TECRA Salmonella Visual Immunoassay ²	ELISA	48 h	International BioProducts Contact: Bob Ward 14780 NE 95th St. Redmond, WA 98052 Phone: 800/729-7611; 425/883-1349 E-mail: myeager@intlbioproducts.com Web: intlbioproducts.com
Transia Card <i>Salmonella</i>	ELISA	7 min	Diffchamb AB FO Petersons Gata 32 SE-421 31 Västra Frölunda, Sweden Phone: +46 -31-742 33 50 E-mail: market.dept@diffchamb.se Web: www.diffchamb.se
Transia Plate <i>Salmonella</i>	ELISA	36 h	Diffchamb AB FO Petersons Gata 32 SE-421 31 Västra Frölunda, Sweden Phone: +46 -31-742 33 50 E-mail: market.dept@diffchamb.se Web: www.diffchamb.se
Transia Plate <i>Salmonella Gold</i>	ELISA	36 h	Diffchamb AB FO Petersons Gata 32 SE-421 31 Västra Frölunda, Sweden Phone: +46 -31-742 33 50 E-mail: market.dept@diffchamb.se Web: www.diffchamb.se
Vidas ICS	Immunoconcentration	24 h	bioMérieux Inc. Contact: bioMérieux Industry 595 Anglum Rd. Hazelwood, MO 63042 Phone: 800/638-4835; 314/731-8500 E-mail: usa@na.biomerieux.com Web: www.biomerieux.com
Vidas SLM ²	Enzyme linked fluorescent assay	48 h	bioMérieux Inc. Contact: bioMérieux Industry 595 Anglum Rd. Hazelwood, MO 63042 Phone: 800/638-4835; 314/731-8500 E-mail: usa@na.biomerieux.com Web: www.biomerieux.com
VIP for Salmonella [Detects <i>Salmonella</i> spp.]	Lateral flow immunoassay	28 h	BioControl Systems, Inc. Contact: Robin Forgey 12822 SE 32nd St. Bellevue, WA 98005 Phone: 800/245-0113; 425/603-1123 E-mail: info@rapidmethods.com

¹Includes enrichment

²AOAC Approved

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