U.S. FOOD & DRUG ADMINISTRATION

Bacteriological Analytical Manual

Chapter 25: Investigation of Food Implicated in Illness

January 2000 Edition

January 2000

www.fda.gov

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Revision History

Original Source: Bacteriological Analytical Manual, Edition 8, Revision A, 1998. Chapter 25.

Introduction

To investigate a food that has been implicated as the causative vehicle in an outbreak of illness, the microbiologist should make certain observations and perform certain tests as a matter of course; further analysis depends on the circumstances of the particular case. It is always crucial to note the general condition of the food sample, such as its consistency, color, and odor. As much information as possible should be obtained about its pre- and post-collection history (**see** Chapter I). Microscopic examination and Gram staining must be carried out, as described in Chapter 2.

To decide what treatments, enrichments, or other tests are needed, the microbiologist should evaluate the data in relation to two types of information: I) the causes epidemiologically associated with the type and condition of the implicated food, and 2) the clinical signs and symptoms observed in afflicted individuals. If possible, clinical microbial isolates (usually from stool specimens) and blood serum samples for serological and biochemical testing should be obtained from patients by way of their physicians.

Table I lists the major microbial or chemical agents of foodborne disease and their commonly associated food sources. Recently reported causative agents of foodborne outbreaks, cases, and deaths are given in Table 2. Clinical symptoms most often associated with specific microbial or chemical agents and their duration are listed in Table 3. Analysts should use these tables as an aid in deciding the most probable, less probable, and least likely associations. The tables should not be used to assume a single cause or to eliminate possibilities entirely.

The information in Tables 1-3 concerns mostly those infections designated as "reportable" in the United States by the centers for Disease Control and Prevention (CDC). This agency, which is the principal source of epidemiologic data on reported foodborne disease outbreaks in the United States, periodically publishes summary surveillance reports of foodborne diseases in the *Morbidity and Mortality Weekly Report* series.

Most reports of foodborne illness are submitted to CDC by state health departments. CDC defines a foodborne disease outbreak as an incident in which at least two (or more) persons experience a similar illness after ingestion of a common food, and epidemiologic analysis implicates the food as the source of the illness. A few exceptions exist; for example, one case of botulism or chemical poisoning constitutes an outbreak. Although CDC's foodborne disease surveillance system has limitations (i.e., except for illnesses linked to chemicals or toxins, sporadic cases of foodborne illness are not reported), the system does provide helpful

epidemiologic insights. The etiologic agent was confirmed in 909 (38%) of the 2397 outbreaks of foodborne disease reported to CDC from 1983 through 1987.

With new pathogens there is an inevitable lag before methods are installed and reporting by clinical and food laboratories becomes routine. Changes in food production or processing may make a food the vehicle or growth medium for microorganisms not previously associated with that product. For example, new varieties of tomatoes that are less acidic than the traditional types might support the growth and toxin production of *Clostridium botulinum*; freezing procedures improved to preserve taste may also preserve microorganisms that are killed in blast freezing. The food microbiologist should be aware that the clinical symptoms and diagnosis of the patient's illness, available when analysis of the food sample must begin, may be preliminary or incomplete. To proceed from the generalities given in the tables to an analytical course of action, the microbiologist must use reason, imagination, and caution.

Acknowledgments

The authors thank the following FDA microbiologists for their contributions to the tables: Wallace H. Andrews, Reginald W. Bennett, Jeffrey W. Bier, Elisa L. Elliot, Peter Feng, David Golden, Vera Gouvea, Anthony D. Hitchins, E. Jeffery Rhodehamel, and Tony T. Tran.

General Reading

For more detailed information and instructions on the step-by-step procedures used in investigating foodborne illness, see the *Compendium of Methods for the Microbiological Examination of Foods*, published by the American Public Health Association of Washington, DC, USA.

Table 1. Number of food-implicated outbreaks in the USA reported to CDC from 1983 to 1987, causative agents, and total and confirmed percentages

Agent		FOOD SOURCE											Total	Total (%)	Con-firmed (%)
		Beef & pork	Poultry	Other meats	Seafood	Milk, eggs, cheese	Other dairy	Baked goods	Fruits & vegs	Salads	Other	Un-known			
Bacterial	*Bacillus cereus*	1	0	0	1	1	0	0	1	0	9	4	16	0.7	1.8
	Brucella	0	0	0	0	2	0	0	0	0	0	0	2	0.1	0.2
	Campylobacter	0	1	0	0	12	0	0	1	1	4	9	28	1.2	0.1
	Clostridium botulinum	1	1	10	10	0	0	0	32	0	6	14	74	3.1	8.1
	Clostridium perfringens	3	4	0	0	0	0	0	0	2	12	3	24	1.0	2.6
	Escherichla coli	1	0	0	0	3	0	0	0	0	3	0	7	0.3	0.8
	Salmonella	25	22	6	3	14	1	4	5	12	78	172	342	14.3	37.6
	Shigella	0	2	1	2	0	0	0	3	7	9	20	44	1.8	4.8
	Staphylococcus aureus	11	3	1	1	1	0	4	1	7	16	2	47	2.0	5.2
	Streptococcus, Group A	0	0	0	0	0	0	0	0	2	2	3	7	0.3	0.8
	Streptococcus, other	0	0	0	0	1	0	0	0	0	1	0	2	0.1	0.2
	Vibrio cholerae	0	0	0	1	0	0	0	0	0	0	0	1	0.0	0.1
	Vibrio parahaemolyticus	0	0	0	1	0	0	0	0	0	0	1	2	0.1	0.2
	Other bacterial	0	0	0	1	2	0	0	0	0	0	1	4	0.2	0.4
Total		**42**	**33**	**18**	**20**	**35**	**1**	**8**	**43**	**31**	**140**	**229**	**600**	**25.2**	**66.0**
Chemical	Ciguatoxin	0	0	0	86	0	0	0	0	0	0	1	87	3.6	9.6
	Heavy metals	0	0	0	0	0	0	0	1	0	12	0	13	0.5	1.4
	Monosodium glutamate	0	0	0	0	0	0	0	0	0	2	0	2	0.1	0.2
	Mushrooms	0	0	0	0	0	0	0	0	0	14	0	14	0.6	1.5
	Scombrotoxin	0	0	0	81	0	0	0	0	0	0	2	83	3.5	9.1
	Shellfish	0	0	0	2	0	0	0	0	0	0	0	2	0.1	0.2
	Other chemical	1	0	0	2	3	3	4	3	1	13	1	31	1.3	3.4
Total		**1**	**0**	**0**	**171**	**3**	**3**	**4**	**4**	**1**	**41**	**4**	**232**	**9.7**	**25.5**
Parasitic	*Giardia*	0	0	0	0	0	0	0	1	0	1	1	3	0.1	0.3
	Trichinella spiralis	24	0	8	0	0	0	0	0	0	0	1	33	1.4	3.6
Total		**24**	**0**	**8**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**2**	**36**	**1.5**	**4.0**
Viral	Hepatitis A	1	0	0	0	0	0	0	1	2	2	22	28	1.2	3.1
	Norwalk virus	0	0	0	1	1	0	0	1	1	4	4	12	0.5	1.3
	Other viral	0	0	0	0	0	0	0	0	0	1	0	1	0.0	0.1
Total		**1**	**0**	**0**	**1**	**1**	**0**	**0**	**2**	**3**	**7**	**26**	**41**	**1.7**	4.5
Confirmed Total		**68**	**33**	**26**	**192**	**39**	**4**	**12**	**50**	**35**	**189**	**261**	**909**	**37.9**	-
Unknown		**34**	**22**	**9**	**42**	**8**	**5**	**11**	**9**	**34**	**220**	**1094**	**1488**	**62.1**	-
Total Outbreaks		**102**	**55**	**35**	**234**	**47**	**9**	**23**	**59**	**69**	**409**	**1355**	**2397**	**-**	-

Table 2. Number and percent of confirmed foodborne disease outbreaks cases, and deaths in the USA reported to CDC from 1983 through 1987, listed by etiologic agent

Etiologic agent		Outbreak		Cases		Deaths	
No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Bacterial	*Bacillus cereus*	16	1.8	261	0.5	0	0.0
	Brucella	2	0.2	38	0.1	1	0.7
	Campylobacter	28	3.1	727	1.3	1	0.7
	Clostridium botulinum	74	8.1	140	0.3	10	7.3
	Clostridium perfringens	24	2.6	2,743	5.0	2	1.5
	Escherichia coli	7	0.8	640	1.2	4	2.9
	Salmonella	342	37.6	31,245	57.3	39	28.5
	Shigella	44	4.8	9,971	18.3	2	1.5
	Staphylococcus aureus	47	5.2	3,181	5.8	0	0.0
	Streptococcus, Group A	7	0.8	1,001	1.8	0	0.0
	Streptococcus, other	2	0.2	85	0.2	3	2.2
	Vibrio cholerae	1	0.1	2	0.0	0	0.0
	Vibrio parahaemolyticus	3	0.3	11	0.0	0	0.0
	Other bacterial	3	0.3	259	0.5	70	51.1
Total		**600**	**66.0**	**50,304**	**92.2**	**132**	**96.4**
Chemical	Ciguatoxin	87	9.6	332	0.6	0	0.0
	Heavy metals	13	1.4	176	0.3	0	0.0
	Monosodium glutamate	2	0.2	7	0.0	0	0.0
	Mushrooms	14	1.5	49	0.1	2	1.5
	Scombrotoxin	83	9.l	306	0.6	0	0.0
	Shellfish	2	0.2	3	0.0	0	0.0
	Other chemical	31	3.4	371	0.7	1	0.7
Total		**232**	**25.5**	**1,244**	**2.3**	**3**	**2.2**
Parasitic	*Giardia*	3	0.3	41	0.1	0	0.0
	Trichinella spiralis	33	3.6	162	0.3	1	0.7
Total		**36**	**4.0**	**203**	**0.4**	**1**	**0.7**
Viral	Hepatitis A	29	3.2	1,067	2.0	1	0.7
	Norwalk virus	10	1.1	1,164	2.1	0	0.0
	Other viral	2	0.2	558	1.0	0	0.0
Total		**41**	**4.5**	**2,789**	**5.1**	**1**	**0.7**
Confirmed Total		**909**	**100.0**	**54,540**	**100.0**	**137**	**100.0**

Source: Bean, N.H., P.M. Griffin, J.S. Golding, and C.B. Ivey. 1990. *Morbid. Mortal. Weekly Rep*. Special Supplement No. 1, Vol. 39.

Table 3. Onset, duration, and symptoms of foodborne illnesses [a1]

Onset and duration of illness		Predominant symptoms	Associated organism or toxin
Upper gastrointestinal tract symptoms (nausea, vomiting) occur first or predominate	Less than 1 h	Nausea, vomiting, unusual taste,burning of mouth.	Metallic chemicals[a]
	1-2 h	Nausea, vomiting, cyanosis, headache, dizziness, dyspnea, trembling, weakness, loss of consciousness.	Nitrites;[b]*Paragonimus* sp.
	Onset 1-6 h, mean 2-4 h, duration 1-2 days	Nausea, vomiting, retching, diarrhea, abdominal pain, prostration.	*Staphylococcus aureus* and its enterotoxins; *Sarcocystis hominis*
	8-16 h (1-4 h rarely)	Vomiting, abdominal cramps,diarrhea, nausea.	*Bacillus cereus*
	6-24 h	Nausea, vomiting, diarrhea, thirst, dilation of pupils, collapse, coma.	*Amanita* species mushrooms;[c] *Sarcocystis suihominis*
Sore throat and respiratory symptoms occur	12-72 h	Sore throat, fever, nausea, vomiting, rhinorrhea, sometimes a rash.	*Streptococcus pyogenes* (Lancefield Group A)
	2-5 days	Inflamed throat and nose,spreading grayish exudate,fever, chills, sore throat,malaise, difficulty in swallowing,edema of cervical lymph node.	*Corynebacterium diphtheriae*
Lower gastrointestinal tract symptoms (abdominal cramps, diarrhea) occur first or predominate	2-36 h, mean 6-12 h	Abdominal cramps, diarrhea, putrefactive diarrhea associated with *C. perfringens*, sometimes nausea and vomiting.	*Clostridium perfringens*, *Bacillus cereus*, *Streptococcus faecalis*, S. *faecium*
	4-120 h, mean 18-36 h, duration 1-7 days	Abdominal cramps, diarrhea, vomiting, fever, chills, malaise, nausea, headache possible.Sometimes bloody or mucoid diarrhea, cutaneous lesions and hypotension associated with *V. vulnificus*; *V. cholerae* OI may cause dehydration, shock; *Yersinia enterocoliticia* mimics flu and acute appendicitis.	*Salmonella* species (including *S. arizonae*), *Shigella*, enteropathogenic *Escherichia coli*, other *Enterobacteriacae*, *Vibrio parahaemolyticus*, *Yersinia enterocolitica*, *Pseudomonas aeruginosa* (?), *Aeromonas hydrophila*, *Plesiomonas shigelloides*, *Campylobacter jejuni* (*coli*), *V. cholerae* (O1 and non-O1), *V. vulnificus*, *V. fluvialis* *V. hollisae*, *V. mimicus*
	1-5 days	Diarrhea, fever, vomiting, abdominal pain, respiratory symptoms; often asymptomatic.	Enteroviruses, rotavirus, enteric adenovirus, Norwalk-like viruses; anisakid nematodes, *Nanophyetus salmincola*; *Cryptosporidium parvum*
	1-6 weeks	Mucoid diarrhea (fatty stools), abdominal pain, weight loss.	*Giardia lamblia* *Nanophyetus salmincola*
	1 to several weeks, mean 3-4 weeks	Abdominal pain, diarrhea, constipation, headache, drowsiness, ulcers, variable; often asymptomatic.	*Entamoeba histolytica* *Isospora belli*
	3-6 months	Nervousness, insomnia, hunger pains, anorexia, weight loss, abdominal pain, sometimes gastroenteritis.	*Taenia saginata*, *T. solium*

Onset and duration of illness		Predominant symptoms	Associated organism or toxin
Neurological symptoms (visual disturbances, vertigo, tingling, paralysis) occur	Less than 1 h	Tingling and numbness, giddiness,staggering, drowsiness, tightness of throat, incoherent speech, respiratory paralysis.	Shellfish toxin[d]
		Gastroenteritis, nervousness,blurred vision, chest pain,cyanosis, twitching, convulsions.	Organic phosphate[e]
		Excessive salivation, perspiration, gastroenteritis, irregular pulse,pupils constricted, asthmatic breathing.	*Muscaria*-type mushrooms[f]
		Tingling and numbness, dizziness, pallor, gastroenteritis, hemorrhage, and desquamation of skin, fixed eyes, loss of reflexes, twitching, paralysis.	Tetraodon toxin[g]
	1-6 h	Tingling and numbness, gastroenteritis, dizziness, dry mouth, muscular aches, dilated eyes, blurred vision, paralysis.	Ciguatera toxin[h]
		Nausea, vomiting, tingling, dizziness, weakness, anorexia,weight loss, confusion.	Chlorinated hydrocarbons[i]
	2 h to 7 days, usually 12-36 h	Vertigo, double or blurred vision,loss of reflex to light, difficulty in swallowing, speaklng, and breathing, dry mouth, weakness, respiratory paralysis, death.	*Clostridium botulinum* and its neurotoxins
	More than 72 h	Numbness, weakness of legs, spastic paralysis, impairment of vision, blindness, coma.	Organic mercury[j]
		Gastroenteritis, leg pain, ungainly high-stepping gait, foot and wrist drop.	Triorthocresyl phosphate[k]
Allergic symptoms (facial flushing, itching) occur	Less than 1 h	Headache, dizziness, nausea, vomiting, peppery taste, burning of throat, facial swelling and flushing, stomach pain, itching of skin.	Histamine[1]
		Numbness around mouth, tingling sensation, flushing, dizziness, headache, nausea, vomiting.	Monosodium glutamate [m]
		Flushing, sensation of warmth,itching, abdominal pain, puffing of face and knees.	Nicotinic acid[n]
	1-7 days	Coughing, asthma.	*Ascaris lumbricoides*
General infection symptoms (fever, chills, malaise, prostration, aches, swollen lymph nodes) occur	4-28 days, mean 9 days	Gastroenteritis, fever, edema about eyes, perspiration, muscular pain, chills, prostration, labored breathing.	*Trichinella spiralis* *Gnathostoma* sp. *Paragonimus* spp. *Alaria* spp.
	7-28 days, mean 14 days >10 months	Malaise, headache, fever, cough, nausea, vomiting, constipation, abdominal pain, chills, rose spots on abdomen, bloody stools	*Salmonella typhi* *Paragonimus westermani*
	10-13 days	Fever, headache, myalgia, rash.	*Toxoplasma gondii*
	10-50 days, mean 25-30 days	Fever, malaise, lassitude, anorexia, nausea, abdominal pain, jaundice.	Etiological agent not yet isolated--probably viral (especially Hepatitis A and E viruses)
	Varying periods (depends on specific illness)	Fever, chills, head- or joint ache, prostration, malaise, swollen lymph nodes, and other specific symptoms of disease in question.	*Bacillus anthracis*, *Brucella melitensis*, *B. abortus*, *B. suis*, *Coxiella burnetii*, *Francisella tularensis*, *Listeria monocytogenes*, *Mycobacterium tuberculosis*, *Pasteurella multocida*, *Streptobacillus moniliformis*, *Campylobacter jejuni* *Leptospira* species

[a] Consider chemical tests for such substances as zinc, copper, lead, cadmium, arsenic, antimony.

[b] Consider nitrites, test for decoloration of blood.

[c] Consider *Amanita* species mushroom poisning. Identify mushrooms species eaten; test urine and blood for evidence of renal damage (SGOT, SGPT enzyme tests).

[d] Consider shellfish poisoning.
[e] Consider organic phosphate insecticide poisoning.
[f] Consider *Muscaria* species of mushrooms.
[g] Consider tetraodon (puffer) fish poisoning.
[h] Consider ciguatera fish poisoning.
[i] Consider chlorinated hydrocarbon insecticides.
[j] Consider organic mercury poisoning.
[k] Consider triorthocresyl phosphate.
[l] Consider scombroid poisoning. Examine foods for *Proteus* species or other organisms capable of decarboxylating histidine into histamine, and for histamine.
[m] Consider Chinese restaurant syndrome caused by monosodium glutamate, a flavor intensifier.
[n] Consider nicotinic acid.
[(a1)] Developed from *Compendium of Methods for the Microbiological Examination of Foods* (1984), pp. 454-457, American Public Health Association, Washington, DC, with permission of the publisher.