*Korean J. Appl. Microbiol. Bioeng.*
Vol. 6, No. 3, 135~140 (1978).

▶ Review ◀

# Microbial Food-Borne Diseases

# (미생물로 인한 품중독)

**S. J. Ro and Y. W. Han**

Department of Home Economics and Microbiology
Oregon State University
Corvallis, Oregon 97331
(Received Sept. 7, 1978)

## Introduction

Food is essential for man and animals. No living thing can exist without an energy source. However, certain foods are harmful to man and animals. The so called "food poisoning" has existed as long as the history of man. Various agents in food can be responsible for illness in human beings. There are foods naturally poisonous such as organs of certain fish, certain mushrooms, and certain weeds which when consumed by cows impart a poison in milk. The addition of chemicals purposely or inadvertently may cause serious illness. Allergy or food idiosyncrasies are well known to many individuals. These are hypersensitivities or reactions which some people show toward certain proteins. The presence of toxins or poisons formed by microorganisms plays a significant role in food poisoning. Food-borne infection by selected types of bacteria which are present in the food prior to its consumption may cause a typical gastrointestinal disturbance.

There are two ways in which microorganisms may cause illness in man. The first is known as food-borne intoxication. Illness is caused by a toxin or poison produced by microorganisms. The other method is foodborne infection in which the organisms are present in the food, enter the host, and grow in the host causing disease.

The subject of food poisoning is very alarming to the public as well as to the public health administrators in the light of frequent outbreaks. We have learned how to control some types of bacterial foodborne intoxications in man, and in recent years have accumulated much information concerning other bacterial diseases of this type. There are a number of review articles on this subject (Esselen et al, 1959; Bryan, 1972; Zottola, 1971). The purpose of this paper is to illustrate various forms of food-borne diseases, especially that caused by microorganisms, in order to help control the diseases by preventing the factors that contribute to the outbreaks.

## Food-Borne Intoxication

Food-borne bacterial intoxication, also called food poisoning, is the illness caused by the ingestion of foods in which certain microorganisms have previously grown and produced toxins. The microorganisms themselves are not harmful, but the toxins they produce cause the illness. The usual symptoms are gastrointestinal upsets, such as cramps, diarrhea, nausea,

and vomiting. Food intoxication is characterized by relatively short incubation period, the duration of symptoms is short and it is seldom accompanied by fever. Microorganisms that are included in this category are *Staphylococcus aureus* and *Clostridium botulinum.*

### 1. Staphylococcal food poisoning

Staphylococcal food-borne intoxication is the most frequent type of food poisoning. Staphylococci liberate a soluble toxin into the food before it is eaten, which is called enterotoxin (entero means intestine). The toxin may produce a marked irritating effect on the gastrointestinal tract. Enterotoxin formed by these organisms is solely responsible for staphylococcal food poisoning. Although staphylococci are pathogenic they cannot cause an infection in the intestinal tract. However, there is some evidence that staphylococcus enterotoxin may affect the central nervous system. One of the unique features of this poisoning is the short incubation period, usually 3 hours after the infected food is consumed. The typical symptoms of this kind of food poisoning are: nausea and vomiting followed by abdominal cramps, severe diarrhea, and prostration. The mortality rate is very low, and in most instances recovery occurs within one or two days.

Staphylococci are widespread in air, water, milk, sewage, and hair and respiratory tracts of animals. High carbohydrate food is an excellent medium for the growth of these organisms. Precooked high protein food, such as meat, milk, eggs, are also potentially dangerous when these foods are improperly refrigerated. Many outbreaks of staphylococcal food poisoning are due to unrefrigerated foods, but food held at 7C is usually safe because enterotoxin is not formed. The presence of enterotoxin in food cannot be detected organoleptically because it does not impart an odor and other symptoms of spoilage. The staphylococcal toxin is quite heat stable—its toxigenicity remains after boiling for 30 minutes.

The most widely used test to determine the toxigenic potential of staphylococci is the coagulase test which indicates the presence or absence of an enzyme able to clot citrated blood plasma.

### 2. Botulism poisoning

Far more serious food poisoning is caused by *Clostridium botulinum,* an anaerobic spore forming bacteria. When favorable conditions exist, this bacteria produces an exotoxin resulting in an acute toxemia when the food is consumed. The spore of this organism is exteWW sumed. The spore of this organism is extremely heat resistant—the spores may remain viable after they have been exposed to boiling water for several hours. However, the toxin is easily destroyed by boiling a few minutes. This phenomenon is very fortunate because the toxin is easily destroyed by cooking.

Several strains of *C. botulium* are recognized by the types of toxin they produce. Types A, B and E toxins are chiefly responsible for human cases of botulism, whereas types C and D affect animals. The toxin has a specific affiinity for the nerve system and is often called neurotoxin.

*C. botulium* is widely distributed in the soil, therefore, is found on fruits and vegetables grown in or near soil. The organism can grow in canned foods where pH is above 4.5. Low acid foods, especially meat, serve as excellent food material for this organism. Fresh foods are usually safe because the foods usually spoil before the toxin can be formed. The incubation period for botulism varies depending upon the amount of ingested toxin, ranging from 8 to 20 hours. Symptoms of botulism are usually fatigue and muscular weakness followed by double vision, dropping of the upper eye lids, dryness of the mouth, swelling of the tongue, and difficulty in swallowing and speaking. There are no gastrointestinal disturbances and death results from a paralysis of the respiratory

muscles. Many improperly preserved foods held at room temperature during the summer months present ideal conditions for the growth of the organism

## Food-Borne Infection

Food-borne infection is an illness caused by the ingestion of a food containing harmful microorganisms. When contaminated food is eaten, the organisms enter the alimentary tract and establish food-borne infection. Dysentery, scarlet fever, streptococcus sore throat, and typhoid fever are typical examples. Usually, a certain incubation period is required before the infecting bacteria can localize and grow in the host. This is a distinct difference between food-borne infection and intoxication. The typical pathogenic organisms include *Salmonella* spp. and *Streptococci* spp.

### 1. Salmonella gastroenteritis

The *Salmonella* group of organisms causes one of the most important communicable diseases. While all of the 1,300 known serotypes of *Salmonella* are pathogenic for man, the following three are most common: *S. enteritis, S. typhimurium,* and *S. newport.* The term *Salmonella* gastroenteritis implies an infection rather than a poisoning, but the *Salmonella* group multiply so rapidly in certain kinds of foods that in a short time they produce symptoms similar to that of food poisoning. The mechanism of food poisoning by the *Salmonella* group is not well understood.

Their reservoir is the intestinal tract of warm blooded animals including man. Therefore, contamination of the food may occur through human carriers, domestic pets, and wild animals. Unclean personal habits are the main source of contamination. Milk, eggs, poultry, and proteinous salads are the common foods which have been frequently reported as the infected foods. Fruits and vegetables are usually free of *Salmonella* unless they are handled in a contaminated environment.

The onset of the symptoms varies from 12 to 36 hours depending upon the number of organisms present in the food. *Salmonella* food poisoning is usually characterized by severe headache followed by chills. As symptoms progress, vomiting, abdominal pain, diarrhea, fever, and prostration usually follow. The symptoms and effects are much more pronounced in young children than in adults. *Salmonella* can be destroyed by thorough cooking. Uncooked foods and food prepared and contaminated by food handlers are dangerous. Principles of sanitation and good manufacturing practices are the most important ways of protecting processed foods from the infection. There is no practical value of immunization against *Salmonella* gastroenteritis.

### 2. *Clostridium perfringens* gastroenteritis

The anaerobic spore-forming bacteria, *Clostridium perfringens* produces toxin inside the human intestinal tract, and its incubation period is about 8 to 22 hours. Diarrhea is a very common symptom and vomiting (common in staphylococcal food poisoning) is very rare and fever (common in Salmonellosis) is almost absent. The organism is widely distributed in the soil, water, sewage, and intestinal tract of humans and animals. The majority of *C. perfringens* gastroenteritis outbreaks are associated with mass feeding establishments where large quantities of foods are prepared and kept at room temperature for a long period of time before serving. The most common vehicles are beef, poultry, and gravy. Control of this food-born disease lies in prevention of multiplication of this organism in foods. Food should be either cooked and served immediately or refrigerated. Raw meats and poultry should be kept separate from cooked foods. Perfringen poisoning is due to massive sporulation of vegatative cells in the intestine accompanied by the release of foreign proteins from the sporangia. Thus, it is closer to intoxication

than infection.

### 3. Streptococcal infections

When a large number of *Streptococcus faecalis* is ingested, an infection type of food poisoning is manifested. The symptoms are relatively mild and no toxins are formed during the growth of the organisms in food. The organisms grow at 12 C to 46 C and show a high degree of salt tolerance. *Streptococcus* causes upper respiratory infection with fever. Most strains are killed at pasteurizing temperatures.

The sources of *S. faecalis* are usually associated with intestinal contents of man and animals. Thus, food-borne outbreaks are largely due to infected food handlers. The incubation period is 2 to 20 hours and symptoms include nausea, abdominal pain, diarrhea, and vomiting, but no fever.

### 4. Vibrio parahaemolyticus gastroenteritis

*V. parahaemolyticus* food poisoning was first observed in Japan from raw fish, shellifish, and cucumbers in brine (Baker et al., 1975). The fast growth rate of the organism is perhaps its most significant characterstic (Lee, 1973). The generation time of 7.6 minutes for this organism is the shortest ever reported for any bacteria (Aiso, 1967). The organism fails to grow at 2 C, but grows at salt concentrations of 1 to 7%. The organism is easily killed by heat.

### 5. Other food-borne infection

During the last decade, food-borne typhoid fever diminished and shigellosis appeared more frequently. Improved sanitation and education of food workers are the cause for the reduced incidence of typhoid fever. *Escherichia coli*, although a normal inhabitant of the intestinal tract, can also cause pathological infection in man and animals. The term "enteropathogenic *E. coli*" (EEC) has been used to designate strains of the organism with the particular potential to cause diarrheal disease (Nester, 1965). *Bacillus subtilis* and *Bacillus cereus* are also reported (Hauge, 1955) to cause food poisioning.

## Infections Other than Bacterial Food Poisoning

### 1. Trichinosis

When encysted larvae of *Trichinella spiralis* (a nematode, occasionally found in muscle tissue of hogs) are ingested, they colonize in the intestine and manifest the symptoms of nausea, vomiting, diarrhea, dysentery, colic and profuse sweating. This infection can be prevented if all pork products are cooked well as the organism is easily killed by heat.

### 2. Amoebic dysentery

*Endamoeba histolytica* (a protozoan) is the causative agent of the illness. Even though amoebic dysentery is not a major cause of food poisoning it can be food-borne. Usually the disease is endemic and spread by contaminated water or by intimate personal contact. Its insidious and chronic nature differentiates it from bacterial food poisoning. The symptoms of amoebic dysentery vary from a mild diarrhea to acute blood flux.

### 3. Viral hepatitis

Infectious hepatitis may be food-borne. Contamination of foods by infected humans is the usual cause of the disease. The incubation period ranges from 10 to 40 days, and the symptoms are headache, fatigue, nausea, chills, vomiting and general malaise. One of the significant problems with the infectious hepatitis virus is that there are no therapeutic or detection methods available (Fugate et al., 1975). Full recovery from hepatitis may take a year.

### 4. O fever

Rickettsia and Coxiella are transmitted by ticks usually associated with the game animals. Common symptoms are sudden fever, chills, headache, bodyaches and pains, coughing, and

bloody sputum. The symptoms are often diagnosed as a typical pneumonia. The illness lasts about one to three weeks, but fatality rate is very low.

### 5. Ptomaine poisoning

The term "ptomaine" has been frequently used to describe any food poisoning. However, ptomaine poisoning should be distinguished from bacterial intoxication. Both are the result of microbial activity under certain conditions. Ptomaines may be associated with decomposition of foods, in which amino acid is decarboxylated to form an amine. In the case of decaying fish, trimethylamine is formed, which may be poisonous to man. Fortunately, it can be detected by the characteristic odor of spoiling food. Scombroid fish poisoning is due to nasosuppressing effect of histamine and other amines produced by the bacterial action on the scombroidal fish. If lysine, another important amino acid in meat is decarboxylated, a typical ptomaine is formed, which is also poisonous. However, not all ptomaines are poisonous. For instance, a characteristic odor produced during cheese making is also a kind of ptomaine. The main difference between bacterial toxin and ptomaines is that the former is produced by internal processes of the bacterial cells and are generally heat labile, whereas the latter are cleavage products resulting from bacterial metabolism of protein under selected conditions and they are not heat labile.

### 6. Fungal toxins (Mycotoxins)

Mycotoxins represent a group of toxic fungal metabolites which have been found to contaminate some foods. The significance of mold-contaminated foods in human diets is not yet well established. However, morbidity and mortality data certainly imply at least the possibility that foods contaminated with mold growth of certain specific types may be responsible for diseases or malignancies and death in humans. Some of these compounds have been shown to have a high order of acute toxicity to certain animals and have exhibited potent carcinogenic properties (Wogan, 1966). Many cases of illness or death in cattle, swine, and other animals are reported to have been caused by mycotoxins contaminating animal feeds. The demonstration of various biological effects resulting from the ingestion of contaminated foods by experimental animals has emphasized the potential public health hazard which might arise from contamination of the food supply by mycotoxins.

Of the more than 200 mycotoxins generated by molds aflatoxin received the most attention. Aflatoxin is a metabolic product of the growth of a common fungus, *Aspergillus flavus*. While it was originally thought that this mold grew preferentially on protein-rich foods, such as nuts, it has since been found in a wide variety of common foods. There has been many controversies on whether or not the *Aspergillus oryzae*, the fungus most widely used in Oriental food preparation, produce aflatoxin. General consensus is that it does not produce toxin in normal practice. There are at least 8 kinds of aflatoxins, the 4 most familiar ones being aflatoxins $B_1$, $B_2$, $G_1$ and $G_2$. These are very heat stable and are unaffected by the usual cooking procedures. Production of some of the toxins is known to be dependent upon conditions of high humidity and temperature.

The potential importance of aflatoxins in human and animal diseases is enormous. It has been suggested that they can be responsible for lethal liver disease of a variety of animals. Numerous workers are investigating the role, if any, of aflatoxins in human liver disease and neoplasia.

## Reference

1) Aiso, K.: Generation time of *Vibrio parahaemolyticus* and the growth in contimated foods. In T. Fujino and H. Fukumi (eds). *Vibrio parahaemolyticus* Ⅱ. p. 345~350.

Nayashoten, Tokyo, Japan (1967).

2) Baker, W. H., R. E. Weaver, G. K. Morris and W. T. Martin: Epidemiology of *Vibrio parahaemolyticus* infection in human. Microbiology, 1975. *Amer. Soc. Microbiol.*, Washington, D. C. p. 257~262 (1975).

3) Bryan, F. L.: Food-borne diseases of contemporary importance. *US EPA Public Health Service.* Center for Disease Control. Atlanta, Georgia (1972).

4) Esselen, W. B. and A. S. Levine: Bacterial food poisoning and its control; A review. *Dept. of Food Technol., Univ. Massachusetts. Bull. No.*, 493 (1959).

5) Fugate, K. J., D. O. Cliver and M. T. Hatch: Enteroviruses and potential bacterial indicators in Gulf coast oysters. *J. Milk and Food Technol.*, **38**(2), 100 (1975).

6) Hauge, S.: Food poisoning caused by spore forming bacilli. *J. Appl. Microbiol.*, **18**, 591 (1955).

7) Lee, J. S.: What seafood processors should know about *Vibrio parahaemolyticus. J. Milk. and Food Technol.*, **36**, 405 (1973).

8) Neter, E.: Enteritis due to enteropathogenic *E. coli. Amer. J. Dig. Dis.*, **10**, 883 (1965).

9) Zottola, E. A.: *Clostridium peringens* food poisoning. *Extension Bulletin*, 365. University of Minnesota (1971).