FOOD CONTAMINATION

Introduction

Food contamination is possible by many factors. One of the factors is pathogenic (disease-causing) organisms such as bacteria, fungi, viruses and parasites, if the food is not properly handled or cooked these organisms will lead to illness. Toxins (poisons) produced by certain microorganisms is another factor contributing to food intoxication (poisoning). Food can also be contaminated (made impure) by chemicals such as pesticides (used in insect and rodent control in kitchens and to manage agricultural infestation), certain cleaning compounds, and sometimes by use of improper containers (pots) for cooking or storing food. These chemicals when ingested in large amounts can cause serious food borne illness.

In this episode let us understand the food contamination in following headings

1. **Microbial contamination of food**
2. **Sources of microorganisms in food**
3. **Food poisoning**
4. **Food borne animal parasites**
5. **Chemical poisoning**

1. MICROBIAL CONTAMINATION OF FOOD

There are several sources of microorganisms which may contaminate food and cause problems of spoilage or create health risks when the food is consumed. It can be seen that most food cannot be sterile but have a natural flora and acquire a transient flora derived from their environment. To ensure that food is safe and can be stored in a satisfactory state, it is necessary to either destroy the microorganisms present or manipulate the food so that growth is prevented or hindered.

Some of the important genera known to occur in foods are as follows. Some are desirable in certain foods; others bring about spoilage or other complications including gastroenteritis.

Bacteria

Acinetobacter, *Erwinia*, *Pediococcus*, *Aeromonas*, *Escherichia*, *Proteus*, *Alcaligenes*, *Flavobacterium*, *Pseudomonas*, *Arcobacter*, *Hafnia*, *Psychrobacter*, *Bacillus*, *Kocuria*, *Salmonella*, *Brochothrix*, *Lactococcus*, *Serratia*, *Campylobacter*, *Lactobacillus*, *Shewanella*, *Carnobacterium*, *Leuconostoc*, *Shigella*, *Citrobacter*, *Listeria*, *Staphylococcus*, *Clostridium*, *Micrococcus*, *Vagococcus*, *Corynebacterium*, *Moraxella*, *Vibrio*, *Enterobacter*, *Paenibacillus*, *Weissella*, *Enterococcus*, *Pantoea*, *Yersinia*, etc.,

Molds

Alternaria, *Cladosporium*, *Mucor*, *Aspergillus*, *Colletotrichum*, *Penicillium*, *Aureobasidium*, *Fusarium*, *Rhizopus*, *Botrytis*, *Geotrichum*, *Trichothecium*, *Byssochlamys*, *Monilia*, *Wallemia*, *Xeromyces*.

Yeasts

Brettanomyces, *Issatchenkia*, *Schizosaccharomyces*, *Candida*, *Kluyveromyces*, *Torulaspora*, *Cryptococcus*, *Pichia*, *Trichosporon*, *Debaryomyces*, *Rhodotorula*, *Zygosaccharomyces*, *Hanseniaspora Saccharomyces*, etc.,

Protozoa

Cryptosporidium parvum, *Entamoeba histolytica*, *Cyclospora cayetanensis*, *Giardia lamblia* and *Toxoplasma gondii*.

The genera and species listed above are among the most important normally found in food products. Each genus has its own particular nutritional requirements, and each is affected in predictable ways by the parameters such as both intrinsic factors (pH, moisture content, oxidation-reduction potential (Eh), nutrient content, antimicrobial constituents, biological structures) and extrinsic (temperature of storage, relative humidity of environment, presence and concentration of gases and presence and activities of other microorganisms). For example, bacteria associated with most perishable food such as some meat products and which are also known to cause food-borne diseases include *Salmonella* spp., thermophilic *Campylobacter* spp., enterohemorrhagic *Escherichia coli* (e.g. serogroup O157; EHEC), some serovars of *Yersinia enterocolitica*, *Listeria monocytogenes*, *Clostridium perfringens*, *Staphylococcus aureus*, *Cl. botulinum*, and *Bacillus cereus*. Meats are also subject to microbial spoilage by a range of microorganisms including *Pseudomonas* spp., *Shewanella*, *Brochothrix thermosphacta*, lactic acid bacteria, members of Enterobacteriaceae, psychrotrophic Clostridia, yeasts, and molds.

Viruses

Much less is known about the incidence of viruses in foods than about bacteria and fungi, for several reasons, first, being obligate parasites, viruses do not grow on culture media as do bacteria and fungi. The usual methods for their cultivation consist of tissue culture and chick embryo techniques. Second, because viruses do not replicate in foods, their numbers may be expected to be low relative to bacteria, and extraction and concentration methods are necessary for their recovery.

Few viruses with high potential as food contaminants are

Picornaviruses: Polioviruses, Coxsackievirus A, Coxsackievirus B, Echovirus, Enterovirus, Hepatitis A,

Reoviruses: Reovirus, Rotaviruses,

Parvoviruses: Human gastrointestinal viruses,

Papovaviruses: Human BK and JC viruses

Adenoviruses: Human adenoviruses.

Prions

In recent years, Bovine Spongiform Encephalopathy (BSE) such as mad cow disease has attracted public health attention. The first cases of BSE were reported in Great Britain in November 1986. It appears probable that the disease can be transmitted to humans by food. The prions that cause the disease are resistant to chemical and physical influences, i.e. to heat, UV, ionizing radiations and disinfectants. Prions are sensitive to certain alkaline substances and moist heat under high pressure. An effective disinfectant measure is steam sterilization at 133°C and 3 bar pressure for 20 min. On the basis of current knowledge, the cause of the BSE epidemic was animal feed (meat- and bone-meal) containing brain, eyes or spinal cord of infected animals, and other tissues that had been inadequately heated during the production process.

2. SOURCES OF MICROORGANISMS IN FOOD

There are several sources contributing to contamination of microorganisms in food such as

Soil and water: These two environments are placed together because many of the bacteria and fungi that inhabit both have a lot in common. Soil being a natural media contains wide range of microorganisms which may enter water through atmosphere. These microorganisms contaminate food if care is not taken.

Air and Dust: Most of the microorganisms listed above may at times be found in air and dust in a food-processing operation. Among fungi, a number of molds may be expected to occur in air and dust along with some yeast. In general, the types of organisms in air and dust would be those that are constantly reseeded to the environment.

Plants and Plant Products: It may be assumed that many or most soil and water organisms contaminate plants. However, only a relatively small number find the plant environment suitable to their overall well-being. Those that persist on plant products do so by virtue of a capacity to adhere to plant surfaces so that they are not easily washed away and because they are able to obtain their nutritional requirements.

Food Utensils:

When vegetables are harvested in containers and utensils, one would expect to find some or all of the surface organisms on the products to contaminate contact surfaces. As more and more vegetables are placed in the same containers, a normalization of the microbiota would be expected to occur. In a similar way, the cutting block in a meat market along with cutting knives and grinders are contaminated from initial samples, and this process leads to a buildup of organisms, thus ensuring a fairly constant level of contamination of meat borne organisms.

Gastrointestinal Tract: The intestinal biota consists of many organisms that do not persist as long in waters as do others, and notable among these are pathogens such as salmonellae. Any or all of the Enterobacteriaceae may be expected in fecal wastes, along with intestinal pathogens, including the protozoal species.

Food Handlers: The microbiota on the hands and outer garments of handlers generally reflect the environment and habits of individuals, and the organisms in question may be those from soils, waters, dust, and other environmental sources. Additional important sources are those that are common in nasal cavities and the mouth and on the skin, and those from the gastrointestinal tract that may enter foods through poor personal hygienic practices.

Animal Feeds: This is a source of salmonellae to poultry and other farm animals. In the case of some silage, it is a known source of *Listeria monocytogenes* to dairy and meat animals. The organisms in dry animal feed are spread throughout the animal environment and may be expected to occur on animal hides.

Animal Hides: In the case of milk cows, the types of organisms found in raw milk can be a reflection of the biota of the udder when proper procedures are not followed in milking and of the general environment of such animals. From both the udder and the hide, organisms can contaminate the general environment, milk containers, and the hands of handlers.

3. FOOD POISOINING

At least three Gram-positive spore forming rods are known to cause bacterial food poisoning: *Clostridium perfringens (welchii), C. botulinum* and *Bacillus cereus.* The incidence of food poisoning caused by each of these organisms is related to certain specific foods, as is food poisoning in general.

Clostridium perfringens food poisoning

The causative organism of this syndrome is a Gram-positive, anaerobic spore-forming rod widely distributed in soils, water, foods, dust, spices, and the intestinal tract of humans and other animals. Based on their ability to produce certain exotoxins, five types are recognized: types A, B, C, D, and E. The food poisoning strains belong to type A, as do the classic gas gangrene strains, but unlike the latter, the food-poisoning strains are generally heat resistant and produce only traces of alpha toxin. Some type C strains produce enterotoxin and may cause a food-poisoning syndrome.

The causative factor of *Cl. perfringens* food poisoning is an enterotoxin. It is unusual in that it is a spore-specific protein; its production occurs together with that of sporulation. All known food-poisoning cases by this organism are caused by type A strains. An unrelated disease, necrotic enteritis, is caused by beta toxin produced by type C strains and is only rarely reported outside New Guinea. Although necrotic enteritis due to type C has been associated with a high mortality rate, food poisoning due to type A strains has been fatal only in elderly or otherwise debilitated persons. Some type C strains have been shown to produce enterotoxin, but its role in disease is unclear.

Botulism

Unlike *Cl. perfringens* food poisoning, in which large numbers of viable cells must be ingested, the symptoms of botulism are caused by the ingestion of a highly toxic, soluble exotoxin produced by *Cl. botulinum* while growing in foods. It is produced by cells growing under optimal conditions, although resting cells have been reported to form toxin as well. The Botulinal Neurotoxins (BoNT) are the most toxic substances known; with purified type A reported to contain about 30 million mouse LD_{50}/mg. The neurotoxins are formed within the organism and released upon autolysis.

***Bacillus cereus* gastroenteritis**

Bacillus cereus is an aerobic, spore-forming rod normally present in soil, dust, and water. It has been associated with food poisoning in Europe since at least 1906. Among the first to report this syndrome with precision was Plazikowski. His findings were confirmed by several other European workers in the early 1950s. The first documented outbreak in the United States occurred in 1969, and the first in Great Britain occurred in 1971.

B. cereus and *B. mycoides* strains from milk have been shown to produce diarrheagenic enterotoxin in 9 days at temperatures between 6°C and 21°C. Varying numbers of isolates of the following species were found also to be enterotoxin producers: *B. circulans, B. lentus, B. thuringiensis, B. pumilus, B. polymyxa, B. carotarum,* and *B. pasteurii. B. thuringiensis* has been isolated from foods, and it apparently produces a Vero-cell active toxin.

B. cereus produces a wide variety of extracellular toxins and enzymes, including lecithinase, proteases, β-lactamase, sphingomyelinase, cereolysin (mouse lethal toxin, hemolysin I), and hemolysin BL. The diarrheagenic syndrome appears to be produced by a tripartite complex composed of components B, L1, and L2 and designated Hemolysin BL (HBL). Together, this complex exhibits hemolysis, cytolysis, dermonecrosis, vascular permeability, and enterotoxic activity.

Mycotoxins

A very large number of molds produce toxic substances designated mycotoxins. Some are mutagenic and carcinogenic, some display specific organ toxicity, and some are toxic by other mechanisms. While the clear-cut toxicity of many mycotoxins for humans has not been demonstrated, the effect of these compounds on experimental animals and their effect in in vitro assay systems leave little doubt about their real and potential toxicity for humans. At least 14 mycotoxins are carcinogens, with the aflatoxins being the most potent. It is generally accepted that about 93% of mutagenic compounds are carcinogens. With mycotoxins, microbial assay systems reveal an 85% level of correlation between carcinogenicity and mutagenesis.

Few mycotoxins detected in food are aflatoxin produced by *Aspergillus flavus, Alternaria* toxins produced by *A. citri, A. alternata, A. solani* and *A. tenuissima,* citrinin mycotoxin produced by *Penicillium citrinum* and other fungi, ochratoxins produced by a large number of storage fungi, including *Aspergillus ochraceus*, *A. alliaceus*, *A. ostianus*, *A. mellus*, and other species of *Aspergilli* and among penicillia that produce ochratoxins are *P. viridicatum*, *P. cyclopium, P. variable,* and others.

Along with these patulin produced by *P. claviforme, P. expansum, P. patulum;* by some aspergilli *(A. clavatus, A. terreus*), Penicillic acid produced by a large number of fungi, including many penicillia (*P. puberulum*) as well as members of the *A. ochraceus* group, sterignatocystin produced by *Aspergillus versicolor, A. nidulans, A. rugulosus* and others, fumonisins produced by *Fusarium* species such as *F. anthophilum, F. dlamini, F. napiforme, F. nygami, F. moniforme,* and *F. proliferation,* sambutoxin (*Fusarium sambucinum* and *F. oxysporum*) and zearalenone (*F. graminearum* and *F. tricinctum*) are of real serious concern in food intoxication.

Even algal toxins such as Dinoflagellate toxins, Cyanobacterial toxins, toxic Diatoms also contribute to food contamination.

4. Food borne animal parasites

The animal parasites that can be contracted by eating certain foods belong to three distinct groups: protozoa, flatworms, and roundworms. In contrast to food borne bacteria, animal parasites do not proliferate in foods, and their presence must be detected by direct means, as they cannot grow on culture media. Because all are larger in size than bacteria, their presence can be detected rather easily by use of appropriate concentration and staining procedures. Because many are intracellular pathogens, resistance to these diseases is often by cellular phenomena similar to that for listeriosis.

Finally, another significant way in which some animal parasites differ from bacteria is their requirement for more than one animal host in which to carry out their life cycles. The definitive host is the animal in which the adult parasite carries out its sexual cycle; the intermediate host is the animal where larval or juvenile forms develop. In some instances, there is only one definitive host (e.g., cryptosporidiosis); in others, more than one animal can serve as definitive host (e.g., diphyllobothriasis); and in still other cases, both larval and adult stages reside in the same host (e.g., trichinosis).

Giardiasis (*Giardia lamblia*), Amebiasis (*Entamoeba histolytica*), Toxoplasmosis (*Toxoplasma gondii*), Sarcocystosis (*Sarcocystis hominis*, *S. suihominis*), Cryptosporidiosis (*Cryptosporidiun parvum*), Cyclosporiasis (*Cyclospora cayetanensis*) are the few examples and along with these other involved in this category are

Flatworms: Which belongs to the animal phylum Platyhelminthes,

Fascioliasis: This syndrome (also known as parasitic biliary cirrhosis and liver rot) is caused by the digenetic trematode *Fasciola hepatica*,

Paragonimiasis: This parasitic disease (also known as parasitic hemoptysis) is caused by *Paragonimus* spp., especially *P. westermani.*

Fasciolopsiasis: Fasciolopsiasis is caused by *Fasciolopsis buski*, and the habitat of this organism is similar to that of *E. hepatica.* Humans serve as definitive host, several species of snails as first intermediate hosts, and water plants (watercress nuts) as second intermediate hosts.

Clonorchiasis: The class Trematoda of the flatworms consists of parasites commonly referred to as flukes that infect the liver, lungs, or blood of mammals. *Clonorchis (Opisthorchis) sinensis* is the Chinese liver fluke that causes oriental biliary cirrhosis.

Roundworms

The disease-causing roundworms of primary importance in foods belong to two orders of the phylum Nematoda.

Trichinosis: *Trichinella spiralis* is the etiological agent of trichinosis (trichinellosis), the roundworm disease of greatest concern from the standpoint of food transmission. The organism was first described in 1835 by J. Paget in London, and the first human case of trichinosis was seen in Germany in 1859. Although most flatworm and roundworm diseases of humans are caused by parasites that require at least two different host animals, the trichinae are transmitted from host to host; no free-living stages exist.

Anisakiasis: This roundworm infection is caused by two closely related genera and species: *Anisakis simplex* (the herringworm or whaleworm) and *Pseudoterranova decipiens* (formerly *Phocanema;* codworm or sealworm). Both of these organisms have several intermediate hosts and generally more than one definitive host.

5. Chemical poisoning

Several pesticides are in use to manage pre and post harvest diseases associated with plants. Pesticides are also used as a preservative for long term seed storage and transport (to avoid biodeterioration by microorganisms). Among the unintended consequences of chemical pesticides for crop protection, is the residue that remains on various crops. This, of course, is cause for concern as pesticides are by their very nature designed to kill pests. It is known to be associated with several ailments in human after consuming pesticides laced food. The amount of pesticide residues present on fruit and vegetables at harvest are creating a residual toxicity among the consumers. Risk assessment relating to pesticide residues in food has been tackled by the Codex Alimentarius with the special Joint FAO/WHO Expert Committee on Pesticide Residues (JMPR) made up of groups of independent experts. This commission carries out toxicological assessments on pesticides, estimating an ADI value, and proposing MRLs and models to be used to assess the population exposure.

On February 3, 2015, the Indian government released a report in the *Economic Times* detailing high levels of pesticide residue in vegetables, fruits, spices, rice, and wheat. India has been monitoring chemical pesticide residues in foods since 2005 as part of the central scheme ‘Monitoring of Pesticide Residues at National Level’ operational since 2005. The current report details pesticide residue levels in food items for the year 2013-14. Another report released by Crop Care Federation of India in December 2014 said one-third of organic products sold in the national capital in the last two years were loaded with pesticides.

Apples, peaches, nectarines, strawberries, grapes, celery, spinach, sweet bell peppers, cucumbers, cherry tomatoes, snap beans, potatoes are considered to be the most pesticides contaminated fruits and vegetables.

These chemical pesticides and heavy metal contamination is a major contributing factor in food related chemical toxicity on animals.

Conclusion

Food is effective target for intentional contamination because there are several chemical, radiological, and biological agents that could be successfully employed, many of which are difficult to isolate and detect in complex matrices like food. Many of the contaminants have little effect on the sensory properties of a food and would not create suspicion for food sellers or consumers. Food products at the greatest risk include those that are perishable, ready-to-eat, and which would be distributed and consumed before there had been time to detect the hazard. Furthermore, food is distributed rapidly, often over great distances, and to large numbers of people in different locations, creating the potential for widespread impact.

According to World Health Organization (WHO), over two million people – 1.5 million of them children – die each year in the world due to diarrhea from contaminated food and water. Out of the two million, nearly 700,000 die in South Asian countries alone. In 2013, about 10 percent of the deaths in India of children below 5 years were due to diarrhea. This warrants need of understanding the sources of microbial and other food contamination and its proper management, before supplied to the consumer.