FOOD SAFETY HAZARDS

Introduction

A food safety hazard can be defined as any factor present in food that has the potential to cause harm to the consumer, either by causing illness or injury. Food safety hazards may be biological, such as pathogenic bacteria, chemical, such as a toxin produced during processing, or a physical object, like a stone or piece of metal. In other words, hazards are the factors that food safety practice seeks to protect against, contain and eliminate from foods. A thorough understanding of biological and chemical hazards is the first essential step for its management. This is less important for physical hazards, which also tend to have a much lower potential impact on public health.

In this session let us understand the food safety hazards in the following topics

- 1. Biological hazards
- 2. Food intoxication
- 3. Chemical hazards
- 4. Allergens
- 5. Physical hazards

1. BIOLOGICAL HAZARDS

It is generally biological hazards that pose the greatest immediate food safety threat to the consumer. For example, the ability of food-poisoning bacteria to cause large outbreaks of acute illness within a short time is a threat with which most food businesses are likely to have to contend. There are few foods that are not vulnerable to biological hazards at some point in their manufacture, storage and distribution.

Technically, biological hazards may include larger organisms, such as insects and rodents. However, these rarely present a direct threat to health. It is microorganisms and certain food borne parasites that are of most concern as food safety hazards. Most food borne bacterial pathogens cause illness by multiplying in the gut after ingestion of contaminated food. They may then provoke symptoms by invading the cells lining the intestine, or in some cases, invading other parts of the body and causing more serious illnesses.

A significant number of bacterial species can be classified as food safety hazards. Some of these, such as *Salmonella* and *Listeria monocytogenes*, are very well known and familiar to consumers, whereas others are much less common and less well understood. Examples include *Vibrio parahaemolyticus*, a comparatively rare cause of food poisoning associated with seafood, and *Yersinia enterocolitica*, a cause of gastroenteritis that predominantly affects young children. *Campylobacter* is another example of a less well known cause of food borne illness. Few consumers have heard of this organism, yet it is now the cause of more reported cases of food poisoning than any other agent, including *Salmonella*. *Campylobacter* is also less familiar to the food industry and there are still many unknowns surrounding its transmission to humans. This underlines the importance of continued research and scientific investigation for increasing our understanding of biological hazards.

Let us understand few bacteria associated with food safety hazards

Campylobacter sp.

Campylobacter is most often associated with fresh poultry meat and related products. A UK Food Standards Agency study has found that the level of poultry carcass contamination in the UK is 50%, but elsewhere studies have found contamination rates of at least 60%, with up to 10^7 *Campylobacter* cells per carcass being recorded. Fresh poultry is more frequently and more heavily contaminated than frozen. *Campylobacter* species have also been isolated from other fresh meats such as beef, lamb, pork and offal, but at lower frequencies than in poultry. *Campylobacter* can also be found in raw milk, shellfish, mushrooms and salads.

The UK Health Protection Agency (HPA) has published guidelines on acceptable levels of micro-organisms in various ready-to eat foods. These state that ready-to-eat foods should be free from *Campylobacter* spp. and that, even in small numbers, their presence in processed, ready-to-eat foods, "results in such foods being of unacceptable quality/potentially hazardous." *Clostridium perfringens*

Clostridium perfringens can be found in low numbers in many raw foods, especially meat and poultry, as the result of soil or faecal contamination. Spores of *Cl. perfringens* will survive many heating and drying processes, and the presence of low numbers of the spores in raw, cooked and dehydrated products is not necessarily a cause for concern because high numbers of vegetative cells are required to cause illness. In addition, research has suggested that only strains of *Cl. perfringens* repeatedly exposed to heating are able to cause food poisoning and that strains freshly isolated from the environment do not. *Clostridium perfringens* food poisoning is a relatively mild form of food poisoning and is caused by strains that produce enterotoxins (it is important to note that not all strains of *Cl. perfringens* are enterotoxin producers).

European Food Safety Authority's (EFSA) Scientific Panel on Biological Hazards has recommended that, "when new or modified products are developed, that might support the growth of *Cl. perfringens* and/or enterotoxin production, processors should ensure that target levels of 105/g are not exceeded under the anticipated conditions of storage and handling." In addition, the UK Health Protection Agency (HPA) has issued guidelines on the microbiological quality of some ready-to-eat foods at the point of sale. These state that levels of *Cl. perfringens* of 100/g to $<10^4$ /g is unsatisfactory in these products, and levels $>10^4$ /g are unacceptable/potentially hazardous.

Similarly Aeromonas sp., Clostridium botulinum, Bacillus sp., Arcobacter butzleri, Enterobacter sakazakii, Enterococcus faecium and Enterococcus faecalis, Listeria monocytogenes, L. innocua, L. welshimeri, L. seeligeri, L. ivanovii and L. grayi, Mycobacterium avium subsp. paratuberculosis, Plesiomonas shigelloides, Pseudomonas aeruginosa, Salmonella enterica (which includes 6 subspecies) and Salm. bongori. Shigella species such as Sh. sonnei, Sh. dysenteriae, Sh. flexneri and Sh. boydii, Staphylococcus aureus, Streptococcus pyogenes and Streptococcus equi subspecies zooepidemicus, Verocytotoxin-producing Escherichia coli (VTEC), Vibrio cholera, Vibrio parahaemolyticus, Vibrio vulnificus, Other Vibrio species associated with food borne disease to a much lesser extent are V. alginolyticus, V. mimicus, V. damsela, V. hollisae and V. fluvialis. Yersinia enterocolitica and Yersinia pseudotuberculosis, some strains of Citrobacter spp. (notably Citrobacter freundii), Klebsiella spp., Providencia spp., Enterobacter spp. and Proteus spp., are considered to play major role in food safety hazards.

Viruses

Viruses are living and nonliving entity of the ecosystem. These are also reported to be food food borne and are component of food safety hazards. Few examples are; Astroviruses which are spherical, positive-sense, single-stranded RNA viruses belonging to the family Astroviridae associated with young children (between 6 months–2 years old), but they can also cause a mild infection in adults.

Hepatitis A virus (HAV) is an enteric virus, which causes a liver disease in humans now known as hepatitis A (previously known by other names including infectious jaundice, viral hepatitis and infectious hepatitis). There are a number of different hepatitis viruses but only the HAV, and possibly the hepatitis E virus, can cause foodborne disease. HAV is a single-stranded RNA virus belonging to the Picornaviridae family and the genus Hepatovirus.

Highly pathogenic avian influenza (HPAI) viruses belong to the family Orthomyxoviridae, and within this family these viruses are in the group known as influenza type-A viruses. Influenza type-A viruses are classified into subtypes, and are named according to two main surface proteins, haemagglutinin ("HA") and neuraminidase ("NA"). For example, the subtype H5N1 has an HA 5 protein and NA 1 protein. To date, 16 HA subtypes, and 9 NA subtypes have been described and many different combinations of HA and NA proteins are known to exist (e.g. H5N1, H1N1, H7N3 and H7N7).

Noroviruses is the name given to a group of related non-enveloped, single stranded RNA viruses that have recently been classified in the family Caliciviridae, genus Norovirus. These highly infectious enteric viruses are a major cause of acute gastroenteritis in humans (the infection is often called viral gastroenteritis). Although many cases are caused by person-to-person spread, the ingestion of contaminated food or water also plays a significant part in their transmission.

The parvoviruses are very small, single-stranded DNA viruses belonging to the family Parvoviridae. These viruses have a smooth surface with no discernable features and were previously included in the group of viruses known as small round viruses (SRVs) or featureless viruses.

Rotaviruses are non-enveloped, double-stranded RNA viruses, which are classified as belonging to the family Reoviridae, genus Rotavirus. There are seven described species or "serotypes" of rotavirus (known by the letters A–G). Although group A rotaviruses are a major cause of acute diarrhoea it is thought that only a small percentage (around 1%) of cases are actually food borne, the main route of transmission is person-to-person through the faecal oral route.

The sapoviruses are a group of single-stranded, positive-sense, RNA viruses recently classified in the family Caliciviridae, genus Sapovirus. Previously, these human caliciviruses

were known as Sapporo-like viruses (SLV), or referred to as classic, or typical caliciviruses. Sapoviruses are commonly associated with causing mild viral gastroenteritis in infants and children worldwide.

Parasites

Along with bacteria and viruses even parasites are also real concern. Few examples are; *Cryptosporidium* is a single-celled protozoan parasite belonging to the subclass *Coccidia*. Until recently, the only species thought to be important in human illness was classified as *Cryptosporidium parvum*. However, recent taxonomic studies have shown that several species can infect humans, including *C. hominis*, which is specific to humans, and *C. parvum*, which infects both humans and ruminants. Other species that have been reported to infect humans include *C. felis*, *C. canis*, *C. meleagridis* and *C. suis*.

Cyclospora is a single-celled protozoan parasite belonging to the subclass Coccidia. The only species known to cause human illness is *Cyclospora cayetanensis*. This species has also been reported in chimpanzees and other non-human primates, rodents and a few other animals, but it is possible that humans are the primary host.

Entamoeba is a single-celled protozoan parasite belonging to the subphylum *Sarcodina*. The species important in human illness is *Entamoeba histolytica*, but at least five other species are also found in humans, notably *Entamoeba dispar*, which is morphologically indistinguishable from *E. histolytica*, but much more common and non-pathogenic.

Giardia is a single-celled flagellate protozoan parasite belonging to the order *Diplomonadida*. The cells are unusual in having two nuclei. The species important in human illness is *Giardia intestinalis* (previously referred to as *G. lamblia*, or *G. duodenalis*). *G. intestinalis* is also found in a number of domestic and wild animals, including cattle, cats and dogs.

Toxoplasma is a single-celled protozoan parasite belonging to the subclass *Coccidia*. The species of significance to human health and food safety is *Toxoplasma gondii*.

Nematodes such as *Anisakis simplex* (whale worm or herring worm), *Pseudoterranova decipiens* (seal worm or cod worm), other related marine nematodes, such as *Contracaecum* spp. and *Hysterothylacium* spp., have been implicated in human infections, but these have only very rarely been reported in developed countries. *Trichinella* is a genus of parasitic nematode worms that can cause a potentially serious infection (trichinellosis or trichinosis) in humans following consumption of infected meat. The other recognised species identified in human cases are *T. britovi*, *T. pseudospiralis*, *T. nativa*, *T. murrelli*, *T. papuae* and *T. nelsoni*, but these are less commonly found than *T. spiralis* and are usually associated with wild animals.

Balantidium coli is a large (70 mm diameter) ciliate protozoan parasite that is normally associated with pigs, although other mammals, including rodents and non-human primates, may also act as reservoirs of infection. Sarcocystis hominis and S. suihominis, Ascaris lumbricoides, Fasciola hepatica, Paragonimus sp. Taenia solium (the pork tapeworm) and Taenia saginata (the beef tapeworm), Diphyllobothrium latum, Echinococcus granulosus, are the other parasites associated with food hazards.

Prions

The infective prion thought to be the causative agent for foodborne vCJD in humans is present in certain tissues of cattle suffering from BSE. High levels of BSE prions are known to occur in the central nervous system, particularly in the spinal cord and the brain.

2. FOOD INTOXICATION

There are a few food borne pathogenic bacteria that produce illness not by infection, but by intoxication. These organisms are able to grow in certain foods under favorable conditions and produce toxins as a by-product of growth. The toxin is thus pre-formed in the food before ingestion and in some cases toxin may still be present even after all the bacterial cells have been destroyed by cooking. *Bacillus cereus* and *Staphylococcus aureus* are examples of bacteria which are able to cause intoxication, but the most important and potentially serious cause of intoxication is *Clostridium botulinum*. Intoxications usually have much shorter incubations times than infections, because the toxins are pre-formed in the food.

Fungal toxins such as Aflatoxin B_1 , B_2 , G_1 and G_2 are also major food safety hazards. Aflatoxin B1 is the most commonly found in food and also the most toxic.

Citrinin is a toxic fungal metabolite (mycotoxin) produced by some moulds of the genera *Penicillium, Aspergillus* and *Monascus* growing on certain food commodities, especially cereals and fruit. It was first isolated from a culture of *Penicillium citrinum* in 1931. Citrinin exhibits a number of toxic effects in animals and its presence in food is undesirable.

Cyclopiazonic acid (CPA) is a toxic fungal metabolite (mycotoxin) produced by some moulds of the genera *Penicillium* and *Aspergillus* growing on a wide range of food commodities. As it can be produced by *Aspergillus flavus*, it has the potential to co-occur with aflatoxins, but there is comparatively little data about its occurrence in foods.

Deoxynivalenol (DON) is a toxic fungal metabolite (mycotoxin) produced by certain plant pathogenic moulds, especially Fusarium species, infecting cereal crops in the field.

Ergots [fungal structures (sclerotia) produced by certain species of *Claviceps* fungi] contain a number of different types of alkaloids, which can produce toxic effects in animals and humans. The effects of these alkaloids have been known for hundreds of years and they were the main cause of outbreaks of a toxic condition known as "St Anthony's Fire", which occurred regularly in Europe during the Middle Ages.

The fumonisins are a group of at least 15 chemically related toxic fungal metabolites (mycotoxins) produced by certain mould species of the genus *Fusarium*, which may colonise cereals, especially maize, in the field. Horses exposed to fumonisins in feed over a period can develop a fatal disease known as equine leucoencephalomalacia (ELEM), which causes neurotoxic effects, liver damage and degeneration in the brain.

Ochratoxins are a small group of chemically related toxic fungal metabolites (mycotoxins) produced by certain moulds of the genera *Aspergillus* and *Penicillium* growing on a wide range of raw-food commodities. Some ochratoxins are potent toxins and their presence in food is undesirable.

Patulin is a toxic fungal metabolite (mycotoxin) produced by certain moulds of the genera *Penicillium*, *Aspergillus* and *Byssochlamys* growing on certain food commodities, especially fruit. Patulin exhibits a number of toxic effects in animals and its presence in food is undesirable.

Sterigmatocystin is a toxic fungal metabolite (mycotoxin) produced by some moulds of the genus *Aspergillus* growing on certain food commodities, such as maize. Sterigmatocystin is a potent carcinogen in animals and its presence in food is undesirable.

Zearalenone is a toxic fungal metabolite (mycotoxin) produced by certain mould species of the genus *Fusarium* colonising cereal crops in the field and during storage. Zearalenone is an oestrogenic mycotoxin well known as a cause of hormonal effects in livestock, especially pigs and sheep.

Aflatrem, *Alternaria* toxins, *Aspergillus clavatus* toxins, citreoviridin, gliotoxin, mycophenolic acid, β -nitropropionic acid, penicillic acid, trichothecene, phomopsins, PR-Toxin, penitrem A, roquefortines, satratoxins, viomellein, vioxanthin and xanthomegnin, walleminol A are the other toxins of concern.

Even plant toxins such as cucurbitacins, Cyanogenic glycosides [occur naturally in many plants, including species of *Prunus* (wild cherry), *Sambucus* (elderberry), *Manihot* (cassava), *Linum* (flax), *Bambusa* (bamboo) and *Sorghum* (sorghum)], furocoumarins, glycoalkaloids, grayanotoxins, lectins, Azaspiracid shellfish poisoning, Amnesic shellfish poisoning, Ciguatera fish poisoning, Diarrhoeic shellfish poisoning, Neurologic shellfish poisoning, Paralytic shellfish poisoning, pufferfish poisoning or fugu poisoning (Tetrodotoxin), caused by toxic algae, biogenic amines, scombrotoxic poisoning which is also known as histamine poisoning are associated with food safety hazards.

3. CHEMICAL HAZARDS

Some of the main classes of chemical contaminant important in food safety are as follows:

- Agricultural chemicals, pesticides, etc.;
- Veterinary drugs
- Natural biological toxins
- Fungal toxins
- Plant toxins
- Fish toxins
- Environmental contaminants (e.g. dioxins and heavy metals)
- Contaminants produced during processing (e.g. acryl amide)
- Contaminants from food-contact materials (e.g. plasticizers)
- Cleaning and sanitizing chemicals
- Adulterants (e.g. illegal food dyes).

Acrylamide, benzene, chloropropanols, furan, polycyclic aromatic hydrocarbons, Bisphenol A (BPA), a phenolic compound also referred to as 2,2-bis(4-hydroxyphenyl)propane,

phthalates (also known as phthalic acid diesters), semicarbazide, dioxins and PCBs (polychlorinated biphenyls), perchlorate, heavy metals such as arsenic, lead, cadmium, tin and mercury, which are used or produced in certain foods during the processing.

Illnesses associated with chemicals in food can be caused by eating a high dose of a chemical contaminant over a short period (i.e. an acute reaction) or by eating a low level of a chemical contaminant over a long period of time (i.e. a chronic reaction).

4. ALLERGENS

In recent years, the problem of food allergy has been growing in importance for the food industry as the number of people, particularly children, affected by allergy symptoms has increased. Food manufacturers have been encouraged to respond to this development, particularly in terms of labeling foods clearly. Along with clear allergen labeling it is their responsibility to ensure that such labels are accurate. When foods are labeled as not containing specific allergens, it is extremely important that they do not become contaminated with those allergens during production. This is vital for allergens such as peanuts, which may cause life-threatening anaphylactic reactions in sensitive individuals. The presence of undeclared allergens in foods is a growing cause of product recalls in Europe, North America and elsewhere.

The control of allergens in food is now a rapidly developing aspect of food safety, which many manufacturers will need to be concerned with. Twelve specific major food allergens are currently recognized by EU legislation, although many more foods are likely to be capable of causing allergic reactions in sensitive individuals.

These are, cereals containing gluten (i.e. wheat, rye, barley, oats, spelt or their hybridized strains), crustaceans, fish, egg, peanuts, soya beans, milk, tree nuts, celery, mustard, sesame seeds and sulfur dioxide and sulfites. It is probable that food allergy will continue to grow in importance in the coming years, and that further allergens will be recognized in legislation.

5. PHYSICAL HAZARDS

Physical contaminants in foods are objects that, under normal circumstances, should not be present in food products. Common contaminants include glass, bone, wood, metal, plastic, rubber, stones and insects.

Food safety concerns associated with physical contaminants include:

- Choking (particularly young children)
- Cuts to the mouth and tongue
- Broken teeth
- Damage to the gastrointestinal system.

Conclusion

Reducing the risk from food safety hazards is an essential part of any food production business – irrespective of its size. It is the responsibility of any industry involved in manufacturing food products, to sell to be aware of and always follow the food regulations relevant to the types of products they are producing.