

Potential Food Hazards: A Review

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Abstract

The food and drink industry is the leading industrial sector globally and has a major contribution to economies worldwide. It can affect people in any part of the world, be it of any race, gender, or income level. The government in developed and developing countries is taking essential measures, concerning the health of end consumers, that are involved in the food chain and are contributing to providing safe food and healthy life. This systematic review covers the relevant issues that are related to food safety, the importance of food safety globally, potential food hazards and their types, techniques to control and prevent food safety hazards, and strategies to manage food safety. It also includes the procedures to be followed to avoid potential hazards.

Introduction

The basic requirement of the human body is food and water, and to maintain proper functioning of the body, a balanced diet is of utmost importance. A balanced diet comprises; a complex range of nutrients that provides energy promotes growth, helps in maintaining good health, and resist disease or any associated illness, and in due course promote longevity. We are well aware of the fact that food and water can carry, or serve as a potential source of microorganisms, chemical compounds, and particulate matter that can cause disease or any kind of illness.

According to the recently estimated values given by World Health Organization (**WHO, 2019**), almost 600 million people in the world become ill annually due to the consumption of contaminated food. It had been noticed that the global food supply chain is impacted by several food safety incidents, like the bovine spongiform encephalopathy (BSE) disaster during the 1990s, and in 1999, the presence of dioxin in the chicken feed was reported, and the repetitive outbreaks of foodborne illness due to *Salmonella* spp. was found in eggs (**Aung and Chang, 2014**)

There are several government agencies and regulations that are working at the local, state, and national levels to set up the rules to produce a safer supply of food. However, this does not guarantee that all food at the retail market and various food services is safe for consumption. Consequently, consumers become an essential part of controlling food safety hazards. It is seen that numerous times, the consumer acquires knowledge from their family members, the media (newspaper, radio, and television), and sometimes from government publications.

Food safety

Food safety is a scientific discipline describing the handling, preparation, and storage of food in ways that prevent foodborne illness. It comprises several routines that should be followed to prevent potentially severe health hazards. Food can serve as a growth medium for disease-causing bacteria which can lead to food poisoning and can spread the disease from person to person. Currently, several debates are going on regarding food safety, which is associated with the impact of Genetically Modified food(GMF) on the coming generations and genetic pollution of the environment, which have severe consequences in deteriorating natural biological diversity.

According to WHO, the five key principles of food hygiene are :

1. Keep clean
2. Separate raw and cooked
3. Cook thoroughly
4. Keep food at safe temperatures
5. Use safe water and raw materials

Importance of food safety

The major health issue that the U.S is facing currently is a foodborne illness and this causes 325,000 hospitalizations and 5000 deaths every year in the country (**Mead *et al*, 1999**). Globally it causes > 1Billion cases of people suffering from food poisoning-related diarrhea annually (**Mead *et al*, 1999**).

According to a study, foodborne illness costs \$1626 per case for the enhanced case model and \$1068 for the basic model. The total annual cost of illness estimated was \$77.7 billion and \$51 billion for the enhanced and basic models, respectively. In the study, the basic cost-of-illness model includes medical costs, productivity losses, and mortality due to illness. While in the enhanced cost-of-illness model, productivity loss estimates are replaced with a more inclusive pain, suffering, and functional disability measure that is based on monetized quality-adjusted life-year approximation (**Scharff, 2012**).

Food illness cases related to microbial pathogens that pose serious health issues in developing countries are estimated to be 10% of total and <1% of total cases are reported in the developing countries (**Satcher,2000**). Consumers have several expectations from food supply like; food should be nutritious and safe at a reasonable cost, variety, and quality are other requirements. The good quality of food is determined by the type and personal choices of an individual. Several important characteristics of quality are freshness, wholesomeness, nutritional value, texture, color, aroma, and flavor.

The food itself cannot cause illness until it is contaminated with disease-causing bacteria or other pathogens. The maximum cases are associated with raw foods of animal origin like meat,

poultry, eggs, fish, shellfish that are frequently contaminated with bacteria commonly present in the food chain. Recently, numerous outbreaks of foodborne illness and the mortality associated with it had called for media and public attention. Therefore, people are more aware, leading to an increase in concern for the safety of foods prepared commercially. This has further lead to providing safe food to consumers.

Food safety and Foodborne illness

Governments of both developed and developing countries are working towards escalating their efforts to pick up food safety. These efforts are taken pertaining to an increasing number of food safety problems and increasing concerns of consumers. Foodborne illness also known as foodborne disease and colloquially referred food poisoning is any illness that results from the spoilage of contaminated food, pathogenic bacteria, viruses, or parasites that contaminate food (CDC,2011), in addition to this prions and several toxins like; aflatoxins, poisonous mushrooms, etc also cause illness.

According to the foodnet data in the US from 2000 to 2007, the CDC estimated 47.8 million foodborne illnesses annually, out of which 9.4 million of the total cases were caused by 31 known pathogens(Scallan *et al*, 2011). The global incidence of foodborne illness is difficult to estimate and as per the reports, 1.8 million people lost their lives from diarrhoeal diseases.

Most foodborne diseases are sporadic and are not reported a majority of times, but still, the outbreaks can take on massive proportions. For example, in 1994, a salmonellosis outbreak occurred in the US due to contamination in ice cream and affected almost 224,000 individuals. In another case, almost 300,000 individuals were affected in an outbreak of hepatitis A in China in 1988, due to consumption of contaminated clams.

Major foodborne diseases from microorganism

Bacteria: Bacteria are the common cause of foodborne illness. In the year 2000, the UK, reported the individual bacteria linked with the infection as follows: *Campylobacter jejuni* 77.3%, *Salmonella* 20.9%, *Escherichia coli* O157:H7 1.4% and others in total less than 0.56% (FSA,UK (2011)).

The common type of bacterial foodborne pathogen are:

Campylobacter jejuni causing campylobacteriosis is a widespread infection, mainly caused by foods such as raw milk, raw or uncooked poultry, and drinking water. The acute symptoms of campylobacteriosis include severe abdominal pain, fever, nausea, and diarrhea. Some cases may lead to chronic health issues, including reactive arthritis, periodontitis, and neurological disorders like Guillain- Barre syndrome (IJFM,2007).

Salmonellosis is caused by *Salmonella* spp. is a major problem in many countries. *Salmonella Typhimurium* infection is caused due to the consumption of eggs and inadequately cooked

poultry products or the other cases are linked with the interactive human-animal pathogens (CDCP,2007)

Escherichia coli 0157:H7 enterohaemorrhagic(EHEC) causes the hemolytic-uremic syndrome. Other foodborne diseases like listeriosis, have emerged over some decades and can have fatal health consequences.

Cholera caused by the bacterium *Vibrio cholerae* can lead to huge economic losses. It affects the intestine and leads to diarrhea. This infection is spread mainly by consuming food or contaminated water (CDC,2019).

Other common food safety problems are:

Some naturally occurring toxins can cause serious health issues, like mycotoxins, cyanogenic glycosides, marine biotoxins, toxins occurring in poisonous mushrooms, etc. Mycotoxins, such as aflatoxins and ochratoxins A are detected at measurable levels in the staple food and their health consequences for the long term are yet to be understood. The enterotoxin can cause illness even when the microorganisms that produced them have been killed. The symptom usually appears rapidly, for example in the case of *Staphylococcus aureus*, the toxins produced to show the symptoms in 1 to 6 hours. It causes diarrhea with or without vomiting and leads to staphylococcal enteritis.

Some unconventional agents cause bovine spongiform encephalopathy (BSE, commonly known as “mad cow disease”), which is linked with variant Creutzfeldt-Jakob(vCJD) causing disease in humans. The majority of times it is caused due to consumption of bovine products containing brain tissues (NIH, 2017)

Metals such as lead and mercury are associated with causing neurological damage in infants and children. While in adults, exposure to cadmium causes kidney damage.

Potential food hazards

There are three major hazards that smallholders should be made aware of are: physical, chemical, and microbiological. They may cause huge economic loss by getting introduced into the food supply at any time during harvesting, processing, transporting, preparing, storing, or serving food. Hazard Analysis Critical Control Point(HACCP) systems that are adapted to the need of smallholders can serve as the most effective way of controlling these hazards.

Physical hazards in food

Physical hazards are caused due by contaminants or foreign bodies like hair, plant stalks, or pieces of plastic and metal that unintentionally get introduced into food products. Certain times they can be naturally occurring objects like, bones in fish that can cause serious injuries in customers (Campden BRI, 2018).

Classification of physical hazards according to Canadian Food Inspection Agency (CFIA) based on likelihood and the severity of food safety the consequences:

- Category I(high likelihood)
- Category II(moderate likelihood)
- Category III(low risk)

The agency also rates the likelihood of occurrence based on the level of control that a food processor has to control the risk :

- Low Risk – Good control measures are established, but minor infractions occur.
- Medium Risk – Some control measures are established, but gaps and inconsistencies occur.
- High Risk - Little or no control established, but major and critical infractions occur.

Methods of preventing common physical hazards

There should be certain systems in place that can help to prevent contamination of food by foreign bodies like; glass, metal fragments, material from worn-out equipment, dust, unwanted or toxic chemicals, and harmful gases. An effective detection and elimination system for screening should be set up in manufacturing and processing to prevent physical hazards (**Codex Alimentarius, 2003**).

Certain types of equipment that are used to detect or remove dangerous material from food in the processing production lines:

- Metal detectors
- Screens, Sieves, filters
- X-ray technology(to detect bone fragments or pits)
- Magnets
- Food radar systems or some visual inspections

Biological hazards in food

Biological hazards are microorganisms like, bacteria, viruses, parasites, or molds, or the substances produced by them, that can cause serious illness in humans.

Major biological hazards:

- Bacteria like; Salmonella spp., pathogenic enterohaemorrhagic *Escherichia coli*, *Campylobacter jejuni*, *Listeria monocytogenes*, *Staphylococcus aureus*, *Bacillus cereus*, *Clostridium perfringens*, *Clostridium botulinum*, some *Vibrio* spp.
- Virus ex: hepatitis A virus, Norwalk viruses, Rotavirus

- Parasites such as; *Toxoplasma gondii*, Cryptosporidia, Giardia spp, *Trichinella spiralis*, *Taenia solium*, *Cryptosporidium parvum*, etc

Sources of biological contaminants: Faecal contamination (animal guts), cross-contamination of food due to unhygienic practices and improper sanitation, contaminated soil, and water, etc. Interaction between certain factors that affect the growth of microorganisms in food is **Temperature, Ph, Water Activity(Aw)**.

Control and prevention

Implementation of Hazard Analysis and Critical Control Point(HACCP) and Good Food Manufacturing Practices(GMPs) can ensure the prevention of biological hazards.

Some processing strategies that can control biological hazards are:

Thermal processing like; cooking and pasteurization, effective cleaning and sanitizing procedures(ex: SSOPs), using proper process controls like, proper storage temperature (cooler and freezer), following food technology like; packaging techniques(modified atmosphere packaging, vacuum packaging), preservatives, and certain processing techniques(dehydration).

Chemical Hazards in food

There are chances that food products can become contaminated with chemical hazards, that are introduced at any stage of food processing and production. Some chemical hazards are produced by ingredients that are natural components of food like, food allergens, mycotoxins, etc. While other ingredients-related hazards such as pesticides, drug residues, heavy metals, and other environmental adulterations are derived from raw materials. Others like marine biotoxins are produced by some harmful algal blooms and these can accumulate in bivalves mollusks. Classification is mainly based on their chemical structures and the symptoms associated. European legislation has organized regulatory limits and authorized detection methods for these compounds(**Visciano et al,2016**).

Some process-related chemical hazards can get introduced in food formulation, for ex; sulfites and other process-related chemicals formed during heating (such as acrylamide). Biogenic amines in food are produced by bacteria by the action of carboxylases and by other environmental factors that cause their formation. Certain technological factors like; additives and aftermaths of packaging are usually used to control their production(**Gardini et al,2020**).

Controlling chemical hazards

The FDA and USDA have specified the number of chemicals that are used in the food industry and have determined that chemicals are acceptable in food products, while these chemical

substances are forbidden for consumption. Proper storage and handling practices are crucial ways of controlling chemical contamination. The equipment cleaning and sanitizing should be done in proper care, to avoid the accumulation of liquid and the chemical used should be USDA recognized. The employee training should be proper and pest control should be done by the professionals. Recently, researchers have reported some new processes to prevent the growth of fungi that leads to mycotoxins production and the use of some plant extracts has shown antifungal potential against aflatoxigenic isolates of *Aspergillus* spp. (Iram et al,2013).

Food safety management system

The system comprises control and assurance activities. Certain preventive measures are followed to avoid contamination or growth of microbes, and their lessening or elimination, can be biological, physical, or chemical (Zweitering et al, 2016).

Biofilm formation that can either be formed at the abiotic or biotic surface(Diaz et al) can be prevented by cleaning and disinfection by chemical substances like, surfactants and alkali compounds(Campana et al,2017). Some biocontrol agents such as *Lactobacillus plantarum* are used as a probiotic and microbial starter in the food industry and different strains of this species produce antimicrobial substances and bacteriocins (Arena et al, 2016). Patriagnani and Lanciotti in 2016, had reported the application of high and ultra-high-pressure homogenization for food safety. It is linked with microbial inactivation and is yet to be implemented in the food industry.

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