Emerging Contaminants in Food and Food Products

Edited by

SESAN ABIODUN ARANSIOLA,
RASAQ OLAJIDE AKINSOLA,
OLABISI PETER ABIOYE,
and NAGA RAJU MADDELA

CRC Press

3 International Regulations in Food Contaminants

Ummulkhair Salamah Ilyasu, Faridah Laraba Tauheed, Jeremiah David Bala, and Mercy Nnaji

3.1 INTRODUCTION

Food makes a significant contribution to human happiness and is a significant source of tension, pleasure, and anxiety. When there are no harmful substances present that could endanger human health, food is deemed safe and hygienic (Hyldelund *et al.*, 2022). Foods and beverages may become polluted and unfit for consumption. Consumers are very concerned about food contamination, whether it comes from a microbiological or chemical source. It may have disastrous implications for both the economy and health. Foodborne illnesses contribute significantly to global health issues and slow economic progress (Balali *et al.*, 2020). Incidents involving food contamination, whether deliberate or accidental, may have an immediate impact on both the consumer who consumes the product and the company that sold it (Gallo *et al.*, 2020). Food becomes contaminated and unsafe to eat when bacteria or other pathogens get into it. It can also be called spoiled food since it contains microorganisms that make it unfit for human consumption. When foods are contaminated with a potentially dangerous agent, food safety is put at risk. Food hygiene is the set of conditions and procedures necessary to guarantee the safety of food from manufacture to ingestion. It is crucial for any food processing method that the finished product be safe to consume (Kamboj *et al.*, 2020). Despite being essential, there's a chance it will be overlooked when developing procedures that are both successful and efficient. Foodborne illness outbreaks result in significant costs for consumers, the food sector, and the economy, which is why food safety is still a top priority. Registrations for food poisoning in England and Wales rose dramatically, reaching a record of over 60,000 cases in 1996 from roughly 15,000 instances in the early 1980s (Kamboj *et al.*, 2020). Human health has always been at risk from contaminated food, and many of the present issues with food safety are not totally new. Foodborne illness remains a significant health concern in both developed and developing countries, despite concerted efforts by governments around the world to guarantee that food supply is safe (Garcia *et al.*, 2020).

Food contamination can occur at any stage of the processing, transporting, distribution, storing, or preparation process. The majority of foodborne diseases are preventable with proper food preparation (Ehuwa *et al.*, 2021). Over 200 illnesses are known to be spread via food. The public and government still place a high importance on preventing food poisoning even though this tendency has reversed in recent years. Foodborne disease is significantly influenced by improper food handling. Incorrect handling of food may be responsible for 97% of all foodborne illnesses linked to food preparation establishments (Augustin *et al.*, 2020). Unfavorable environmental factors, poor personal hygiene, insufficient and low-quality water sources, and improper preparation of food, storage, and feeding, especially among the lowest socioeconomic strata, increase the possibility of cross-infection and food contamination (Saeed *et al.*, 2021). Food hygiene issues can lead to foodborne diseases and consumer fatalities. Tainted food is among the leading causes of gastrointestinal illness (such as nausea, acute diarrhea, vomiting, and stomach discomfort), impaired nutritional status, lowered ability to fight off sickness, and decreased output in the modern world (Lebelo *et al.*, 2021). When food is purchased, stored, prepared, and consumed according to

DOI: 10.1201/9781003438236-4

acceptable food hygiene guidelines, gastrointestinal illnesses caused by tainted food can be mostly avoided (Gizaw, 2019). The World Health Organization (WHO) has long acknowledged that food workers need to be informed of their responsibilities to maintain food security. The Ten Golden Rules for Safe Food Preparation were released in the early 1990s, and the Five Keys to Safer Food were issued by the WHO in 2001. In acknowledgment of the importance of healthy food for human well-being, and to ensure safe food throughout food processing i.e. from production to consumption, WHO selected "Food Safety" as the 2015 World Health Day Theme (Al-Kandari *et al.*, 2019).

3.2 FOOD CONTAMINANTS

Any substance that is present in food and has the potential to harm consumers is known as a food contaminant. Environmental pollution of soil, water, and air can contaminate food; this pollution is caused by Polychlorinated biphenyls or heavy metals like lead, cadmium, and mercury (Kamboj *et al.*, 2020; Aransiola et al., 2022). PCBs are currently found in the water, soil, and air in several places due to their widespread use as coolants and in several other goods. Pesticides and packaging materials, as well as during cooking or processing, could contaminate food (Khalid *et al.*, 2021). Furthermore, certain pesticides, petrochemicals, and industrial solvents are examples of "endocrine-disrupting" chemicals that may change hormone levels and impact the endocrine system of the body, altering the body's growth and development, immune system performance, the function of the neurological system, as well as the emergence of certain cancers. They may also encourage obesity.

3.2.1 Various Types of Food Contaminants

Contaminants can be divided into four categories:

1. Physical contaminants
2. Chemical contaminants
3. Biological contaminants
4. Allergic contaminants

3.2.1.1 Chemical Contaminants

All types of chemicals that contaminate food are considered chemical contaminants. Any chemical that comes into contact with food has the potential to contaminate it chemically; considering the frequency of chemical usage in kitchens for disinfection and cleaning, food contamination is not surprising (Mohiuddin, 2019). Contamination may occur when cleaning products are sprayed near exposed food or during the preparation of food on a surface that still has chemical residue on it. Additionally, food may be contaminated with chemicals outside of the kitchen (Li *et al.*, 2021). For instance, when food was growing, pesticides and fertilizers might have been applied nearby. Other examples include mycotoxins, organic contaminants from food processing, such as acrylamide and dioxins, and heavy metals like lead and mercury (Aransiola *et al.*, 2019; Abioye *et al.*, 2021). Many environmental factors can also cause chemical contamination during primary production, including runoff of certain substances from animal feed, landfills, incinerators, pollution, polluted land, and waste from factories, contaminated water, and weather conditions like wet conditions at crucial times during growth and harvest that can unintentionally introduce contaminants (Ukaogo *et al.*, 2020).

3.2.1.2 Physical Contaminants

Physical contamination happens when a physical object gets inside food while it's being produced or prepared (Kamboj *et al.*, 2020). Physical items in meals often introduce biological pollutants that can seriously injure the patient, sometimes resulting in choking or broken teeth. Physical contaminants present in food include pieces of cloth, hair, plastic, stones, bones, and insect carcasses

3.4.3 Contamination Related to Cleaning Processes

Disinfection and cleaning are crucial for preventing the contamination of food as they eliminate possible germs during food processing (Maes *et al.*, 2019). Cleaners and disinfectants need to be law-approved and suitable for areas where there is contact with food. Glass cleaners and other metal cleaners may leave hazardous residues behind, so using them is not advised. It is important to quantify the residual chemicals present in the food to ensure that they have been completely removed. Even in minimally processed fruits and vegetables, the addition of sanitizers in quantities far above permitted levels may still leave some residual concentration on treated materials or food (Kamboj *et al.*, 2020). Quaternary ammonium compounds, such as dodecyl-trimethyl-ammonium chloride, and nonionic surfactants, like stearyl alcohol ethoxylate, are examples of common surfactants. Variables such as water temperature or length of rinse can impact how well it removes from different types of surfaces. To analyze these materials, liquid chromatography-mass spectrometry is widely employed. The problems with residues left on food handling equipment surfaces after cleaning and disinfecting products are applied, as well as how they can contaminate the food that touches those surfaces, have been examined by several authors (Zheng *et al.*, 2020).

3.5 CONTAMINATION RELATED TO HEATING STEPS

High temperatures for cooking, when combined with outside influences, can result in the creation of hazardous chemicals, which can negatively impact the safety and quality of food. Certain food processing techniques, such as baking, roasting, heating, canning, grilling, hydrolysis, or fermentation, can result in the production of certain hazardous substances (Ehuwa *et al.*, 2021). These substances include acrylamides, nitrosamines, chloropropanols, furanes, and polycyclic aromatic hydrocarbons (PAHs). The cooking method that can introduce the widest range of hazardous substances into the meal is by far frying. Flavor-producing chemicals are produced when frying oil which is oxidized reacts with nitrogen, proteins, and sulfur compounds in the food. Discoloration or bad flavors are accentuated by the release of various chemicals into the frying oil from the food. The surface of fried food may also absorb coloring from the frying oil. A recent EFSA study reports that in the majority of population groups, the average daily contact with 3-monochloro-1,2-propanediol (3-MCPD) was less than 1 mg/kg b.w. Additional sources of 3-MCPD include migration from epichlorohydrin resins used to maintain humidity in cellulose and paper materials commonly used in sausage casings, as well as the hydrolysis of acids of products containing soybeans, wheat, as well as other vegetable proteins (Makroo *et al.*, 2020). Additionally, significant pollutants resulting from heating procedures are acrylamide and its precursors. Heat-induced reactions between natural food ingredients and food additives may also produce certain processing contaminants, such as nitrosamines. Some foods that have been dried or roasted over direct heat have been found to contain nitrosodimethylamine. The amount of nitrosamine produced during boiling or vapor cooking (which indicates lower temperatures, 100°C) is less than that produced during frying, roasting, or grilling. Numerous methods can be used to evaluate them, such as spectroscopic and colorimetric techniques used after liquid or gas chromatography (GC) or measuring chemically emitted nitric oxide to ascertain the total N-nitroso group. GC coupled to an exact thermal energy analyzer (TEA) detector is the most used, complex, and successful analytical procedure for identifying unstable nitrosamines. Other processing pollutants produced while heating comprise PAHs, which are common in smoked and grilled foods, coffee, and canned or jarred food together with furan derivatives and other products, such as ethyl carbamate (Liu *et al.*, 2022). A range of antecedents, such as the breakdown of carbohydrates and amino acids, ascorbic acid, and the oxidation of fatty acids, can result in furan, which adds to the unpleasant food's flavor. In the lack of fat, mutagen generation is significantly reduced. Model mixes with iron salts and lipids were heated while in contact with Maillard precursors such as glycine, glucose, and creatinine. As a result, among the mutagenic substances, substituted imidazoquinoxalines were found. Tocopherol did not prevent the process,

pathogens are influenced by combinations of these unusual environmental risk variables, which in turn affect the possibility of contaminated goods (Yang *et al.*, 2019). Produce can get contaminated "on-field" by pathogens through several different channels, such as exposure to contaminated water (during floods or irrigation), transmission by insects, usage of untreated compost and manure absorption from contaminated soils and groundwater, air deposition, and fecal contamination from livestock or wild animals (Chang *et al.*, 2020).

3.4 CONTAMINATION OF FOOD DURING MANUFACTURE

Contamination occurs when undesired materials, like particles and dust, are present during the procedures for production and transportation (Abebe, 2020). The process or the product quality is affected by these impurities. Research indicates that food contamination is a major concern among consumers, whether it be chemical or microbiological. Sample treatment devices have been created and recommended as helpful tools for food analysis, such as microextraction techniques that can eliminate matrix interferences and focus the sample's analysis (Xia *et al.*, 2019). It is still difficult to detect the pollutants, regardless of whether they originate from the production, processing, or packaging of food. The contaminants that are most likely to exist throughout every phase of the production of food need to be understood. The paragraphs that follow list the main pollutants in each phase and provide information on ways to reduce or eliminate their presence in food. This information must be used to detect the source of the pollutants in the finished food.

3.4.1 External Raw Food Contamination

Identifying the contaminants remains challenging, regardless of their source, that is, food production, food processing, or food packaging. Food pollutants may be present due to factors such as industrial development, improvements in the usage of agrochemicals, or urban activities (Lebelo *et al.*, 2021). Since pesticides and fertilizers can harm a person's health if consumed, they are major sources of concern when it comes to food pollution. Not only have studies discovered pesticide residues in fruits and vegetables, but they have also identified pesticide derivatives with adverse effects in fatty foods, like metabolites from organochlorine pesticides. Food can become contaminated by known hazardous heavy metals found in the air, soil, and water, such as mercury, cadmium, lead, and arsenic. The amounts of heavy metals in a variation of foods have been measured, including potatoes, tea, salmon, spinach, and honey (Nuray & Arici, 2021). Graphite furnace atomic absorption spectrometry (GFAAS), cold vapor atomic absorption spectrometry (CVAAS), flame atomic absorption spectrometry (FAAS), inductively coupled plasma atomic emission spectrometry (ICP-AES), and ICP mass spectrometry (ICP-MS) are the primary techniques used to analyze heavy metals. To find antibiotic residues found in dairy, eggs, and meat, several methods have been developed, including the liquid chromatography methods and the plate test for microbial inhibition (Moga *et al.*, 2021).

3.4.2 Food Transport Related Contamination

Food contaminants resulting from transportation are an additional possibility. It could be caused by vehicle exhaust containing gasoline or diesel, or it could also result from cross-contamination in a food delivery truck. Food safety is seriously threatened by this cross-contamination (Kamboj *et al.*, 2020). There was a significant disease epidemic throughout the European Community in 1999, and it was traced back to the transportation and storage of materials used in food packaging on pallets tainted with fungicide. Cross-contamination from other sources or disinfection chemicals has also been common on cargo ships traveling vast distances (Joardder *et al.*, 2019).

TABLE 3.1
The Most Commonly Implicated Etiological Agents in Fresh Produce Borne Illnesses

Bacteria	Fungi	Viruses	Parasites
Aeromonas sp.	*Alternaria* sp.	*Calicivirus*	*Ascaris* spp.
Bacillus cereus	*Aspergillus niger*	*Hepatitis A virus*	*Cryptosporidium parvum*
Brucella spp.	*Fusarium* sp.	*Norovirus*	*Cyclospora*
Campylobacter spp.		*Norwalk and Norwalk-like virus*	*Giardia* sp.
Enterobacter spp.		*Rotavirus*	*Toxoplasma gondii*
Escherichia coli		*Sapovirus*	*Trichinella* spp.
Listeria monocytogenes			*Trichuris trichiura*
Pseudomonas spp.			
Salmonella spp.			
Shigella spp.			
Staphylococcus spp.			
Vibrio spp.			
Yersinia spp.			

Source: Balali *et al.* (2020).

(Onyeaka *et al.*, 2020; Musa *et al.*, 2024). Additionally, problems with the facilities or equipment related to food, like missing screws or peeling paint on a piece of machinery, could also end up in the food. Physical pollutants pose a much greater risk because they have the potential to spread dangerous microorganisms (Zhang *et al.*, 2020).

3.2.1.3 Biological Contaminants

Food is said to have undergone biological contamination when living things or their components contaminate it. This comprises biological products made by humans, insects, rodents, and bacteria (Thompson & Darwish,2019). Biological contamination is a major cause of food waste and deterioration, and it is also the predominant source of foodborne illnesses and food poisoning. Foodborne illnesses can be caused by six different types of microorganisms: fungi, viruses, bacteria, parasites, and protozoa (Vidyadharani *et al.*, 2022; Babaniyi *et al.*, 2023). Table 3.1 shows some etiological agents that are commonly isolated from fresh produce. Foodborne illness occurs when pathogens or bacteria that cause disease get into food and multiply to dangerous proportions before being consumed. One single-cell bacterium can grow to two million in just seven hours under the right conditions for bacterial growth, showing how quickly this can happen.

3.2.1.4 Allergic Contaminants

A food that triggers an allergic reaction can contaminate other foods, leading to allergic contamination (Soon, 2019). For instance, if regular bread and gluten-free bread are cut with the same knife, or if spaghetti is kept in a container that was used to keep peanuts previously, even a tiny quantity of a food can have fatal effects on someone who has a food allergy (Tufail *et al.*, 2023).

3.3 SOURCES AND PATHS OF FOOD CONTAMINATION

Food contamination may come from a variety of origins and pathways, and much study has been done to pinpoint the precise processes by which pathogens infect fresh produce (Kumar *et al.*, 2019). Various manufacturing zones have various produce contamination sources and pathways. This is due to the unique combinations of environmental risk factors that each farm has, including terrain, interactions between different land uses, and climate. The incidence and spread of foodborne

and oxidized lipids and iron salts promoted it. Although unrelated to the fried substrate, some of the carcinogenic activity of fat frying is caused by nitrogen-free lipid-hydroperoxide breakdown products (Kamboj *et al.*, 2020). Foodstuffs are being heated in homes and some corporate settings more and more often using the microwave. The fact that food gets cooked inside of its packaging (such as a container or wrapping film) when it is microwaved is a typical feature of microwave cooking. Plastics, paperboard, and composites are examples of such microwave-safe packaging materials. When microwave cooking occurs, many of these materials' components—such as stabilizers, monomers, plasticizers, and antioxidants, among others—could move from the container into the food. Food safety and quality are reduced as a result (Amaregouda *et al.*, 2022). Microwaves can also speed up diffusion, cause migrants or polymers to degrade, or create hot spots, all of which would speed up migration above what is predicted by the bulk heating temperature.

3.6 CONTAMINATION DURING FOOD PACKAGING

Among the many advantages of food packaging are barrier protection, physical safety, and improved food protection, all of which increase the projected life of the product. The food and the packing material may interact directly or indirectly, causing these chemicals to migrate from the container to the meal. Migrants may pose a risk to consumers' health if they have an adverse influence. Strong legislation is in place in the FDA, Europe, Mercosur, and Australia, among many other countries, to protect consumers and stop food from becoming contaminated when it comes into contact with materials or objects. Food packaging materials cannot be used in Europe unless they observe the framework Regulation (EC) No 1935/2004 on things and products that would come in contact with the food and the Regulation (EC) No 2023/2006 on good manufacturing preparation. The European Commission's Regulation EU/10/2011 must be followed to transition away from plastic food contact materials. Any material with a molecular weight of less than 1000 amu can move through layers of paper or polymeric materials, find its way to food, and break down there. When food is packaged in metallic cans, the food may absorb metallic ions such as tin or iron as a result of corrosion on the metallic surface of the can. Cyclo-di-BADGE, bisphenol A, and bisphenol A diglycidyl ether (BADGE), among other minor byproducts from the production of epoxy resins, can migrate to food. Another material that's commonly used to package beans, vegetables, sauces, and jams is glass. Here, the metal covers that were used to seal the glass jars are the cause of migration. One of the substances used in PVC as a plasticizer is epoxidized soybean oil (ESBO), and it has been reported by several authors that ESBO can seep into food.. Products like rice, cereal, frozen dinners, and dry commodities like flour or sugar are commonly packaged using materials like paper and board. Foodstuffs may transfer from printing inks or paperboard additives. The majority of packaging materials are recycled, but using recycled materials might result in food contamination from additives like plasticizers or mineral oils that come from printing inks or adhesives. Common polymers used in packaging food materials include polyvinyl chloride (PVC), polystyrene (PS), polyethylene terephthalate (PET), high-density polyethene (HDPE), and polycarbonate (PC). Most emphasis has been paid to the migration of photoinitiators from UV-curable inks, such as both 2-isopropyl thioxanthone (ITX) and benzophenone (BP) (Sanches-Silva *et al.*, 2009). Migration from printing ink-based components has been discovered to be caused by set-off transference more recently. The fact that recycled plastic items could include chemicals from food that have been packaged in the past, chemicals from consumers misusing the packaging, or intrinsic pollutants (chemical additives) from the recycling process makes them especially important. The compounds known as non-intentionally added substances (NIAS) are added to food packing materials on purpose, and they may contaminate food and cause adverse effects. Degradation processes of the additives employed in the polymer, as well as methods by which the polymer itself degrades, are caused by high temperatures or high irradiation energy encountered during the polymer's manufacturing. NIAS may also be brought on by contaminants in the unprocessed materials.

3.7 CONTAMINATION THROUGH STORAGE

The environment under which food is stored has an imperative effect on the quality and safety of food. Food shelf life is influenced by the kind of product, how it is packaged, and the storage environment, particularly humidity and temperature. Shelf life is increased by proper storage. Packaging materials with strong barrier qualities should be utilized to store food for an extended period of time because food storage shouldn't cause changes in the organoleptic properties of the food. Moisture can cause some packaging materials to deteriorate (metal rusting and paper degeneration, for example). The optimal temperature range is chilly to moderate, or 4–21°C. Direct sunlight can accelerate the deterioration of both the packaging and the food. It was demonstrated that the barrier qualities will affect how different chemicals move through the packing material.

3.8 EFFECTS OF FOOD CONTAMINANTS ON HUMANS

Those who consume tainted food may have a range of negative impacts, including foodborne illness: food poisoning, which can result in symptoms, including nausea, vomiting, diarrhea, fever, and stomach discomfort, is the most frequent consequence of food contamination (Thompson & Darwish, 2019). In severe cases, food poisoning can be fatal, particularly for kids, elderly people, and those with weakened immune systems. Chronic conditions including cancer, liver damage, and neurological diseases can be brought on by prolonged exposure to specific chemicals or toxins found in tainted food. Additionally, food poisoning can have a substantial financial impact, particularly on food producers and eateries. A food recall or epidemic can result in lost sales, legal action, and reputational harm for a business (Sonone *et al.*, 2020). Food contamination is a major public health concern that annually results in foodborne illnesses that impact people all over the world. Chronic illnesses like cancer or acute poisoning can result from chemical contamination. Several foodborne contaminations carry the risk of becoming deadly or leaving a victim permanently disabled. Foodborne illnesses, whether contagious or toxic, are often caused by bacteria, viruses, parasites, or chemicals that infect food or drink and infiltrate the body. A number of the most commor foodborne illnesses, including *Campylobacter*, *Escherichia coli*, and *Salmonella*, harm millions o people yearly and frequently have grave or even deadly consequences. Certain foods, such as egg poultry, and other products derived from animals, have been connected to salmonellosis outbreak Drinking water, raw milk, and undercooked or raw poultry are the main foods that can spre *Campylobacter* infections. Fresh fruits and vegetables, undercooked meat, and unpasteurized mi are all sources of *E. coli* (Abebe *et al.*, 2020).

3.9 INTERNATIONAL AGENCIES THAT REGULATE FOOD CONTAMINATION

The two principal international organizations that govern food contamination are the following: WHO and the Food and Agriculture Organization (FAO).

3.9.1 World Health Organization

The United Nations' special agency for global public health is known as the WHO. The Organiz has 6 regional offices with 150 field offices spread across the globe, with the main office locat Geneva, Switzerland (Cueto, 2023). The WHO was founded on April 7, 1948, and its first c ence was held on July 24 of the same year. It brought together the resources, staff, and duties Office International d'Hygiène Publique in Paris and the International Classification of Di (ICD) of the League of Nations Health Organization. After a substantial influx of funds and nology, the agency began operations in earnest in 1951 (Iliffe, 2023). The stated goal of the is to protect and promote world health as well as security while aiding the most vulnerable. provides countries with assistance technically; they also set health standards worldwide, c

data on these issues, and host discussions on public policy and science in the area of health. The official publication of the organization, the World Health Report, provides evaluations of issues about global health. The WHO specifically assisted in the elimination of smallpox, the creation of an Ebola vaccine, and the nearly total elimination of polio (Cohen, 2019). Presently, its main priorities are diseases that are communicable like COVID-19, HIV/AIDS, malaria, tuberculosis, and Ebola; occupational health; appropriate nutrition; food security; and all of the above. There are also non-communicable diseases like cancer and heart disease on the list. The group advocates for universal healthcare access, involvement in monitoring public health issues, coordination of emergency medical response plans, and overall promotion of health and wellness. At the international and national levels, WHO seeks to improve its capability to prevent, to detect, and to respond to public health concerns connected with contaminated food (World Health Organization [WHO], 2021). Sustaining life and fostering health depend on having access to adequate and safe food. Contaminated food can cause over 200 different ailments, ranging from cancer to diarrhea, by containing harmful parasites, bacteria, viruses, or chemicals. An estimate of 600 million people worldwide every year, or one in ten people, become unwell after consuming food that is contaminated, which leads to 420,000 fatalities and the loss of 33 million years of good living (Balali *et al.*, 2020).

3.9.2 Origin and Founding of WHO

The first of the International Sanitary Conferences (ISC) was convened on June 23, 1851, and they continued for approximately 87 years, until 1938. The primary focus of the inaugural conference, held in Paris, was cholera, which would continue to be the ISC's top concern for the majority of the 1800s (Cueto *et al.*, 2019). It was challenging to get a worldwide consensus on the right course of action because the etiology (causality) and the communicability of several epidemic diseases were still up for debate among scientists. Seven of these international conferences took place during a 41-year period before any of them resulted in a multi-state international agreement. At last, a convention was formed at the seventh session, which took place in Venice in 1892. Its main goal was to oversee ships hygienically passing through the Suez Canal to stop cholera from spreading (Alaggio *et al.*, 2022). Five years later, in 1897, 16 of the 19 states in attendance at the Venice conference signed a convention on the bubonic plague. Even though the US, Sweden-Norway, and Denmark did not ratify this agreement, everyone agreed that the previous conferences' work should be codified for practical use. The diseases that the ISC was concerned about were expanded in subsequent conferences, which took place between 1902 and 1938. Topics covered included the ISC's response to brucellosis, leprosy, tuberculosis, typhoid, and yellow fever (Rudnicka *et al.*, 2020). The Pan-American Sanitary Bureau (1902) and the Office International d'Hygiène Publique (1907) were established swiftly, partly as a result of the conferences' findings. The Health Organization was a part of the League of Nations when it was founded in 1920. The WHO was created by the United Nations through the merger of all previous health organizations after World War II.

3.9.3 Establishment of WHO

At the UN Conference on International Agency in 1945, Chinese delegate Szeming Sze met with representatives from Brazil and Norway to explore the creation of an international health agency under the newly formed UN. Conference secretary-general Alger Hiss proposed utilizing a declaration to establish such an entity when a resolution on the subject was not passed. A proclamation was made as a result of the efforts of Sze and other delegates to hold a global health conference (Cohen, 2019). The term "world" was employed instead of "international" to emphasize the truly global nature of the organization's objectives. The WHO's charter was signed on July 22, 1946, by 51 United Nations members as well as 10 other nations. It became the first UN-specialized agency that every member subscribed to as a result. The 26th member state officially ratified its constitution on April 7, 1948, the first World Health Day, bringing it into compliance (Cueto, 2023). On July

quickly utilize, replicate, and adapt for various target audiences (Gallo *et al.*, 2020). The poster lists the prerequisites for avoiding foodborne illnesses. More than 40 languages have been utilized to translate it, and it is currently being used to promote the WHO's message about food hygiene around the globe (WHO, 2021). The main messages of WHO's five solutions to safer food are the following:

1. Separate cooked food from raw.
2. Cook completely.
3. Keep clean.
4. Store food at safe temperatures.
5. Utilize safe raw materials and clean water.

3.13 HAZARD ANALYSIS CRITICAL CONTROL POINTS PRINCIPLES

The Hazard Analysis Critical Control Points (HACCP) approach was recommended by the Food and Drug Administration in its 1999 FDA Model Food Code as "the most effective and efficient way to assure that food products are safe". HACCP is based on scientific and technical concepts that guarantee food safety (Olaimat *et al.*, 2020). In order to lower the risk of contracting a foodborne illness, the system provides a framework for tracking the food supply chain from harvest to consumption. According to Motarjemi and Warren (2023), the food industry, which encompasses food service, today believes that HACCP and its guiding principles are the best means of avoiding and minimizing foodborne illness. In order to provide safe food for the US space program, the Pillsbury Company created and implemented HACCP for the first time in the late 1950s. State and federal authorities have accepted the HACCP method. It was made mandatory in January 1998 that all seafood processors who ship their products across state lines must implement HACCP procedures (Olaimat *et al.*, 2020). USDA started requiring HACCP plans to be in place for meat and poultry processing facilities in 1998 as well. HACCP concepts serve as the foundation for many state and local food regulatory authorities' inspection procedures. In certain cases, these agencies may even demand HACCP plans for certain food items (Bettridge *et al.*, 2022). The HACCP principles are now the foundation around which food safety instructors design their programs. Whether in a factory that processes food or a restaurant, food is tracked throughout the institution utilizing the seven stages of HACCP. The examination and management of physical, chemical, and biological hazards are covered in the seven phases of the HACCP system. The "Hazard Analysis and Critical Control Point Principles and Application Guidelines" were updated by the National Advisory Committee on Microbiological Criteria for Foods in August 1997. The purpose of these principles is to make it easier to create and execute HACCP plans that work.

3.14 SANITARY AND PHYTOSANITARY MEASURES (SPS)

Sanitary and Phytosanitary (SPS) measures include quarantine and biosecurity protocols that are used to safeguard human, animal, or plant life as well as health from the introduction, establishment, and spread of pests and diseases, as well as from the additives, toxins, and contaminants originating from food and feedstuff (Abdisa *et al.*, 2023; Sanitary and Phytosanitary [SPS], 2023). The Agreement on the Application of SPS Measures (the SPS Agreement) and the Committee on SPS Measures (the SPS Committee) of the World Trade Organization (WTO) regulate these measures. The SPS Agreement gives WTO Members the authority to employ SPS measures to safeguard the health or welfare of people, animals, or plants. A level of protection that each WTO member deems necessary to safeguard human, animal, or plant life as well as health within its borders may be maintained. It is referred to as appropriate level of protection (ALOP) (SPS, 2023).

International Biological Program (IBP) in 1967 after realizing that the depletion of these resources was an important issue in 1961. To do this, it worked with the UN General Assembly to create the largest humanitarian organization devoted to eradicating hunger and promoting food security—the UN World Food Programme.

3.11 REGULATIONS/LAWS THAT GOVERN FOOD CONTAMINATION INTERNATIONALLY (*CODEX ALIMENTARIUS*)

All food is covered under the *Codex Alimentarius*, regardless of whether it is raw, semi-processed, or processed. The *Codex Alimentarius* has techniques for evaluating the security of foods produced utilizing present-day biotechnology in addition to comprehensive guidelines covering subjects including food labeling, food additives, hygiene, and pesticide residues (van der Meulen, 2019). Additionally, it contains management guidelines for official, or government, food import and export certification and inspection programs. The *Codex Alimentarius* is published in six official UN languages: Arabic, Chinese, English, French, Spanish, and Russian of course. Not every text is accessible in every language (Lee et al., 2021). The 78 guidelines (of which 18 included contaminants) and 221 commodity standards, 53 codes of practice, and 106 maximum values for food pollutants are all part of the Codex Alimentarius Commission (CAC) and were all current as of 2017 (Chen *et al.*, 2021). According to a 2018 article from the CAC, "Codex has occasionally come under fire for taking too long to do its job, however, extensive consultation is required when developing food standards and combining them into a reliable, authoritative code". Furthermore, gathering and analyzing evidence, conducting follow-up and verification, and occasionally reaching an agreement that satisfies opposing viewpoints all take time. An average Codex standard takes 4.2 years to produce, but pesticide MRLs and food additive levels take far less time.

3.11.1 History of CAC

The FAO of the United Nations formed the CAC in early November 1961, and the WHO joined it in June 1962. The CAC is responsible for developing and updating the Codex formulas. In October 1963, the first meeting took place in Rome (Čapla *et al.*, 2022). Upholding ethical norms in the global food trade, promoting commerce internationally, and protecting consumer health are the Commission's main goals. In the CAC, an intergovernmental body, the member countries of the WHO and FAO send delegates. There were 189 members of the CAC (188 member countries plus one member organization, the European Union [EU]) and 239 Codex observers (59 intergovernmental organizations, 164 non-governmental organizations, and 16 United Nations organizations) as of 2021. The earliest of these committees, the Joint FAO/WHO Expert Committee on Food Additives (JECFA), was established in 1956 and came before the CAC (Lee *et al.*, 2021). The scientific data that the FAO and WHO scientific committees offer is used by the CAC to develop food standards. "Creating global food standards for permitted food additives" that include maximum levels in food, maximum limits for toxins and contaminants, maximum residue limits for pesticide and veterinary medications used on animals, and norms of conduct for technological function and cleanliness are the main responsibilities of the CAC (van der Meulen, 2019).

3.12 INTERNATIONAL BEST PRACTICES IN FOOD HANDLING TO PREVENT CONTAMINATION

The Five Keys to Safer Food poster was first released by the WHO in 2001 after realizing the need to convey concise, evidence-based messaging as well as the need to give nations' resources they c

24, 1948, the World Health Assembly's first summit came to an end. It was allocated US$5 million (then £1,250,000) for 1949. The appointment of G. Brock Chisholm as director general of the WHO followed his service as executive secretary and a founding member throughout the organization's planning phases. The first president of the assembly was Andrija Tampar. Controlling the spread of malaria, TB, and STDs as well as enhancing nutrition, environmental hygiene, and maternity and child health were its top targets. Accurate statistics on the incidence and severity of sickness were the subject of its first legislative act. The WHO's logo features the Rod of Asclepius, which is a symbol of health (Iliffe, 2023).

3.10 FOOD AND AGRICULTURE ORGANIZATION (FAO)

The United Nations' FAO is a specialized organization that manages global initiatives to end hunger and enhance nutrition and food security. Fiat panis, its Latin motto, translates to "Let there be bread". October 16, 1945, was the date of its establishment. The organization has field offices and regional offices all around the world in addition to its headquarters in Rome and Italy, with operations in over 130 countries. The FAO supports governments and development organizations in organizing their initiatives to advance and develop fisheries, forestry, agriculture, water, and land resources (Calicioglu *et al.*, 2019). It also conducts research, provides technical support for projects, organizes training and educational programs, and aggregates data on agricultural productivity, advancement, and output. FAO offers specialized guidance on food quality and safety, particularly about food additives, pollutants, and chemical residues from animal and agricultural operations.

3.10.1 History of FAO

American activist and agriculturalist David Lubin, who was born in Poland, played a significant role in advancing the notion in the late 19th and early 20th centuries of an international organization for agriculture and food. Italy's King Victor Emmanuel III established the International Institute of Agriculture (IIA) in response to an international conference that took place in Rome and Italy in May and June of 1905 (Bélanger & Pilling, 2019). The International Agricultural Alliance (IIA) was the pioneering intergovernmental body to address the issues and difficulties surrounding global agriculture. Collecting, compiling, and distributing agricultural data which included output estimates and a list of crop diseases was its principal responsibility. One of its accomplishments was the first agricultural census, which was published in 1930 (Pashentsev *et al.* 2020). World War II effectively put an end to the IIA. The League of Nations Conference on Food and Agriculture was held in 1943, during World War II, and was called to order by America President Franklin D. Roosevelt. Delegates from 44 nations traveled to the Hot Springs, Virginia Omni Homestead Resort, May 18–June 3, 1943 to attend the conference. The conference w primarily motivated by Australian economist Frank L. McDougall, who is of British origin. Sin 1935, he has pushed for the creation of an international conference to discuss hunger and malnutrition. At the end of the conference, a resolution was passed to establish an ongoing FAO, wh was accomplished in Quebec City, Canada, on October 16, 1945, in accordance with the FA Constitution (Calicioglu *et al.*, 2019). That same day, the FAO Conference's first session got un way in the Château Frontenac in Quebec City and ran until November 1, 1945. The Perma Committee of the IIA formally dissolved the organization on February 27, 1948, following conflict. After that, its mandate, assets, and operations were shifted to the recently formed F which continued to have its main office in Rome. In its early years, the FAO promoted researc agriculture and nutrition and offered member nations technical support to increase productivi forestry, fisheries, and agriculture (Pashentsev *et al.*, 2020). It concentrated on developing l yield grain varieties, eradicating protein deficiencies, fostering rural employment, and boo agricultural exports starting in the 1960s. The FAO established a cooperative partnership wi

Adopting SPS measures is permitted, but it also comes with responsibilities to reduce the adverse effects of such measures on global commerce. The fundamental requirements are that SPS measures have to

- be used only to the degree required to safeguard the health or well-being of people, animals, or plants, and not to impose more trade restrictions than are necessary
- be supported by adequate scientific data and grounded in scientific principles
- not amount to unfair or irrational treatment or a covert impediment to global trade (SPS, 2023)

3.15 INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

International Organization for Standardization (ISO) is an autonomous, non-governmental global organization. It convenes professionals from around the world to reach consensus on optimal methods for anything from manufacturing to process management. The organization creates and disseminates international standards in all technical and nontechnical domains with the exception of electrical and electronic engineering, which is the purview of the International Electrotechnical Commission (Sgobba, 2022). The ISO has created over 24,676 standards as of February 2023, ranging from technology and manufactured goods to food safety, agriculture, and healthcare (International Organization for Standardization [ISO], 2023).

There are 167 national members that represent ISO in their respective countries as of 2022 with each country having a single member (ISO, 2023). There are three membership tiers for ISO.

- *Member bodies* are national organizations that are regarded as each nation's most representative standards body. These are the only ISO members who are eligible to vote.
- *Correspondent members* are the nations without an independent body for standards. Although they are not involved in the development of standards, these members are aware of the ISO declarations.
- *Subscriber members* are countries with minor economies. They can adhere to the standards' development, but they pay lower membership dues.

Observing members are referred to as "O" members, while participating members are called "P" participants (ISO, 2020).

3.16 CONCLUSION

Food laws have been developing globally to control food safety throughout the past six decades. The population's health is significantly impacted by food systems that prioritize food security, food safety, and wholesome nutrition. Established in 1963 by FAO and WHO, the CAC aims to "develop harmonised international food standards, guidelines and codes of practise to protect health" and to encourage uniformity in all food standards work carried out by international governmental and non-governmental bodies. Strict international laws are required to guarantee the safety of the food we eat because of how intricate and interwoven the global food supply chain is today. While we celebrate accomplishments of past years, we must also acknowledge that continued international cooperation, strict monitoring protocols, and unceasing research are necessary to remain ahead of new pollutants and emerging threats. Through establishing a shared commitment to open communication, data exchange, and standardized guidelines, the global community can strengthen its defenses against foodborne illnesses, protecting public health, and advancing a safe and secure global food supply for future generations. Raising public knowledge of the dangers to food safety is mostly the responsibility of scientists as well as the general outcry of the public. The food sector needs to take the lead. Sensible self-interest indicates that strict but equitable food safety regulations are required to maintain and expand the food trade.

REFERENCES

Abdisa, T., Getu, M., & Etana, M. (2023). Review on Sanitary and Phytosanitary Agreement, *Journal of Veterinary Health Science*, 4(2), 53–63.

Abebe, G. M. (2020). The Role of Bacterial Biofilm in Antibiotic Resistance and Food Contamination, *International Journal of Microbiology*, 2020. https://doi.org/10.1155/2020/1705814

Abebe, E., Gugsa, G., & Ahmed, M. (2020). Review on Major Food-Borne Zoonotic Bacterial Pathogens, *Journal of Tropical Medicine*, 2020. https://doi.org/10.1155/2020/4674235

Abioye, O. P., Ijah, U. J. J., Aransiola, S. A., Auta, S. H., & Ojeba, M. I. (2021). Bioremediation of Toxic Pesticides in Soil Using Microbial Products. In: Prasad R., Nayak S. C., Kharwar R. N., & Dubey N. K. (eds), *Mycoremediation and Environmental Sustainability. Fungal Biology*. Springer, Cham. https://doi.org/10.1007/978-3-030-54422-5_1

Alaggio, R., Amador, C., Anagnostopoulos, I., Attygalle, A. D., Araujo, I. B. D. O., Berti, E., ... & Xiao, W. (2022). The 5th Edition of the World Health Organization Classification of Haematolymphoid Tumours: Lymphoid Neoplasms, *Leukaemia*, 36(7), 1720–1748.

Al-Kandari, D., Al-abdeen, J., & Sidhu, J. (2019). Food Safety Knowledge, Attitudes and Practices of Food Handlers in Restaurants in Kuwait, *Food Control*, 103, 103–110.

Amaregouda, Y., Kamanna, K., & Gasti, T. (2022). Biodegradable Polyvinyl alcohol/carboxymethyl Cellulose Composite Incorporated with l-Alanine Functionalized MgO Nanoplates: Physicochemical and Food Packaging Features, *Journal of Inorganic and Organometallic Polymers and Materials*, 32(6), 2040–2055.

Aransiola, S. A., Ijah, U. J. J., Abioye, O. P., & Bala, J. D. (2019). Microbial-Aided Phytoremediation of Heavy Metals Contaminated Soil: A Review, *European Journal of Biological Research*, 9(2), 104–125. http://www.journals.tmkarpinski.com/index.php/ejbr/article/view/157

Aransiola, S. A., Ijah, U. J. J., Abioye, O. P., & Bala, J. D. (2022). Vermicompost-Assisted Phytoremediation of Toxic Trace Element-Contaminated Soil in Madaka, Nigeria Using *Melissa officinalis* L and *Sida acuta*, *International Journal of Environmental Science and Technology*. http://dx.doi.org/10.1007/s13762-022-04105-y

Augustin, J. C., Kooh, P., Bayeux, T., Guillier, L., Meyer, T., & Jourdan-Da Silva, N., ... & Anses Working Group on Consumer Information on Foodborne Biological Risks (2020). Contribution of Foods and Poor Food-Handling Practices to the Burden of Foodborne Infectious Diseases in France, *Foods*, 9(1), 1644.

Babaniyi, B. R., Ogundele, O. D., Bisi-omotosho, A., Babaniyi, E. E., & Aransiola, S. A. (2023). Remediation Approaches in Environmental Sustainability. In Maddela, N. R., Eller, L. K. W., & Prasad, R. (eds), *Microbiology for Cleaner Production and Environmental Sustainability*. Pp. 321–346 CRC Press. England https://www.routledge.com/Microbiology-for-Cleaner-Production-and-Environmental-Sustainability-Maddela-Eller-Prasad/p/book/9781032496061

Balali, G. I., Yar, D. D., Afua Dela, V. G., & Adjei-Kusi, P. (2020). Microbial Contamination, an Increasing Threat to the Consumption of Fresh Fruits and Vegetables in Today's World, *International Journal of Microbiology*, 2020. https://doi.org/10.1155/2020/3029295

Bélanger, J., & Pilling, D. (2019). *The State of the World's Biodiversity for Food and Agriculture*. Food and Agriculture Organization of the United Nations (FAO). Rome, Italy.

Bettridge, J., Thomas, L. F., Mutua, F. K., Pal, H., & Grace, D. (2022). Review of food safety training in low- and middle-income countries.

Calicioglu, O., Flammini, A., Bracco, S., Bellù, L., & Sims, R. (2019). The Future Challenges of Food and Agriculture: An Integrated Analysis of Trends and Solutions, *Sustainability*, 11(1), 222.

Čapla, J., Zajác, P., Ševcová, K., Čurlej, J., & Fikselová, M. (2022). Milk and Diary Products–Summary of European Legislation, Hygiene Manuals, ISO Standards and Codex Alimentarius Standards, *Journal of Food Sciences*, 16. 431

Chang, X., Xue, Y., Li, J., Zou, L., & Tang, M. (2020). Potential Health Impact of Environmental Micro- and Nanoplastics Pollution, *Journal of Applied Toxicology*, 40(1), 4–15.

Chen, C., Frank, K., Wang, T., & Wu, F. (2021). Global Wheat Trade and Codex Alimentarius Guideline for Deoxynivalenol: A Mycotoxin Common in Wheat, *Global Food Security*, 29, 100538.

Cohen, J. M. (2019). "Remarkable Solutions to Impossible Problems": Lessons for Malaria from the Eradication of Smallpox, *Malaria Journal*, 18, 1–16.

Cueto, M. (2023). The World Health Organization. In: Raviglione, M.C.B., Tediosi, F., Villa, S., Casas N., Plasència, A. (eds) Global Health Essentials. Sustainable Development Goals Series. Springer, Cham. https://doi.org/10.1007/978-3-031-33851-9_63.

Cueto, M., Brown, T. M., & Fee, E. (2019). *The World Health Organization: A History*. Cambridge University Press, Cambridge.

Ehuwa, O., Jaiswal, A. K., & Jaiswal, S. (2021). Salmonella, Food Safety and Food Handling Practices, *Foods*, 10(5), 907.

Gallo, M., Ferrara, L., Calogero, A., Montesano, D., & Naviglio, D. (2020). Relationships between Food and Diseases: What to Know to Ensure Food Safety, *Food Research International*, 137, 109414.

Garcia, S. N., Osburn, B. I., & Jay-Russell, M. T. (2020). One Health for Food Safety, Food Security, and Sustainable Food Production, *Frontiers in Sustainable Food Systems*, 4, 1.

Gizaw, Z. (2019). Public Health Risks Related to Food Safety Issues in the Food Market: A Systematic Literature Review, *Environmental Health and Preventive Medicine*, 24, 1–21.

Hyldelund, N. B., Frederiksen, C., Byrne, D. V., & Andersen, B. V. (2022). Is Stress Taking the Pleasure Out of Food?, *A Characterization of the Food Pleasure Profiles, Appetite, and Eating Behaviors of People with Chronic Stress. Foods*, 11(13), 1980.

Iliffe, J. (2023). The Creation of Group Consciousness among the Dockworkers of Dar es Salaam 1929–50. In *The Development of an African Working Class*. Editor: Richard Sandbrook and Robin Cohen. Routledge, Dar es salaam (pp. 49–72). ()

International Organization for Standardization (ISO). (2020). Archived from the original on 24 January 2020. Retrieved 17 February 2023.

International Organization for Standardization (ISO). (2023). Archived from the original on 17 February 2023. Retrieved 17 November 2023.

Joardder, M. U., Hasan Masud, M., Joardder, M. U., & Masud, M. H. (2019). Harmful Side Effects of Food Processing, *Food Preservation in Developing Countries: Challenges and Solutions*, 153–173.

Kamboj, S., Gupta, N., Bandral, J. D., Gandotra, G., & Anjum, N. (2020). Food Safety and Hygiene: A Review, *International Journal of Chemical Studies*, 8(2), 358–368.

Khalid, F., Hashmi, M. Z., Jamil, N., Qadir, A., & Ali, M. I. (2021). Microbial and Enzymatic Degradation of PCBs from E-Waste-Contaminated Sites: A Review, *Environmental Science and Pollution Research*, 28, 10474–10487.

Kumar, S., Prasad, S., Yadav, K. K., Shrivastava, M., Gupta, N., Nagar, S., Bach, Q.V., Kamyab, H., Khan, S.A., Yadav, S., & Malav, L. C. (2019). Hazardous Heavy Metals Contamination of Vegetables and Food Chain: Role of Sustainable Remediation Approaches-A Review, *Environmental Research*, 179, 108792.

Lebelo, K., Malebo, N., Mochane, M. J., & Masinde, M. (2021). Chemical Contamination Pathways and the Food Safety Implications Along the Various Stages of Food Production: A Review, *International Journal of Environmental Research and Public Health*, 18(11), 5795.

Li, C., Zhu, H., Li, C., Qian, H., Yao, W., & Guo, Y. (2021). The Present Situation of Pesticide Residues in China and Their Removal and Transformation during Food Processing, *Food Chemistry*, 354, 129552.

Maes, S., Heyndrickx, M., Vackier, T., Steenackers, H., Verplaetse, A., & De Reu, K. (2019). Identification and Spoilage Potential of the Remaining Dominant Microbiota on Food Contact Surfaces after Cleaning and Disinfection in Different Food Industries, *Journal of Food Protection*, 82(2), 262–275.

Makroo, H. A., Rastogi, N. K., & Srivastava, B. (2020). Ohmic Heating Assisted Inactivation of Enzymes and Microorganisms in Foods: A Review, *Trends in Food Science & Technology*, 97, 451–465.

Moga, A., Vergara-Barberán, M., Lerma-García, M. J., Carrasco-Correa, E. J., Herrero-Martínez, J. M., & Simó-Alfonso, E. F. (2021). Determination of Antibiotics in Meat Samples Using Analytical Methodologies: A Review, *Comprehensive Reviews in Food Science and Food Safety*, 20(2), 1681–1716.

Mohiuddin, A. K. (2019). Chemical Contaminants and Pollutants in the Measurable Life of Dhaka City, *Journal of Environmental Science and Public Health*, 3(1), 57–73.

Motarjemi, Y., & Warren, B. R. (2023). Hazard Analysis and Critical Control Point System (HACCP). In *Food Safety Management* (pp. 799–818). Academic Press, Cambridge, MA.

Musa, I. O., Auta, H. S., Ilyasu, U. S., Aransiola, S. A., Makun, H. A., Adabara, N. U., Abioye, O. P., Aziz, A., Jayanthi, B., Maddela, N. R., & Prasad, R. (2024). Micro and Nanoplastics in Environment – Degradation, Detection, Ecological Impact, *International Journal of Environmental Research*, 18, 1. https://doi.org/10.1007/s41742-023-00551-9

Nuray, D. A. Ğ, & Arici, Ö. K. (2021). Heavy Metals in Soils Pb (Lead), Hg (Mercury), Cd (Cadmium), As (Arsenic) Effects on Human Health, *International Journal of Environmental Trends (IJENT)*, 5(2), 48–59.

Olaimat, A. N., Shahbaz, H. M., Fatima, N., Munir, S., & Holley, R. A. (2020). Food Safety during and after the Era of COVID-19 Pandemic, *Frontiers in Microbiology*, 11, 1854.

Onyeaka, D. A., Rudakova, E. N., Matvienko, S. V., Shutikova, N. S., & Shchebrenko, E. D. (2020). History of the Establishment and Activities Food and Agriculture Organization of the United Nations (FAO). *Вопросы истории*, (5), 140–145.

Rudnicka, E., Napierała, P., Podfigurna, A., Męczekalski, B., Smolarczyk, R., & Grymowicz, M. (2020). The World Health Organization (WHO) Approach to Healthy Ageing. *Maturitas*, 139, 6–11.

Saeed, B. Q., Osaili, T. M., & Taha, S. (2021). Foodborne Diseases Risk Factors Associated with Food Safety Knowledge and Practices of Women in Sharjah-United Arab Emirate. *Food Control*, 125, 108024.

Sanitary and Phytosanitary (SPS) Measures. (2023). https://www.agriculture.gov.au/biosecurity-trade/market-access-trade/wto/sps#:~:text=Sanitary%20and%20phytosanitary%20(SPS)%20measures,contaminants%20in%20food%20and%20feed

Sgobba, T. (2022). Policy Standards and Technical Standards Development and Use. *Journal of Space Safety Engineering*, 9(3), 410–413.

Sonone, S. S., Jadhav, S., Sankhla, M. S., & Kumar, R. (2020). Water Contamination by Heavy Metals and Their Toxic Effect on Aquaculture and Human Health Through Food Chain. *Letters in Appied. NanoBioScience*, 10(2), 2148–2166.

Soon, J. M. (2019). Food Allergen Knowledge, Attitude and Practices among UK Consumers: A Structural Modelling Approach. *Food Research International*, 120, 375–381.

Thompson, L. A., & Darwish, W. S. (2019). Environmental Chemical Contaminants in Food: Review of a Global Problem. *Journal of Toxicology*, 2019, 1–14.

Tufail, T., Rasheed, Y., Ain, H. B. U., Arshad, M. U., Hussain, M., Akhtar, M. N., & Saewan, S. A. (2023). A Review of Current Evidence on Food Allergies during Pregnancy. *Food Science & Nutrition*, 11(8), 4432–4443.

Ukaogo, P. O., Ewuzie, U., & Onwuka, C. V. (2020). Environmental Pollution: Causes, Effects, and the Remedies. In *Microorganisms for Sustainable Environment and Health*. Editors: Pankaj Chowdhary, Digvijay Verma, Abhay Raj, Yusuf Akhter. Elsevier, Nigeria (pp. 419–429).

van der Meulen, B. (2019). Impact of the Codex Alimentarius. *European Food and Feed Law Review*, 14(1), 29–50.

Vidyadharani, G., Vijaya Bhavadharani, H. K., Sathishnath, P., Ramanathan, S., Sariga, P., Sandhya, A., Subikshaa, S., & Sugumar, S. (2022). Present and Pioneer Methods of Early Detection of Food-Borne Pathogens. *Journal of Food Science and Technology*, 59(6), 2087–2107.

World Health Organization (WHO). (2021). Action framework for developing and implementing public food procurement and service policies for a healthy diet.

Xia, L., Yang, J., Su, R., Zhou, W., Zhang, Y., Zhong, Y., Huang, S., Chen, Y., & Li, G. (2019). Recent Progress in Fast Sample Preparation Techniques. *Analytical Chemistry*, 92(1), 34–48.

Yang, J., Zhao, Y., Li, M., Du, M., Li, X., & Li, Y. (2019). A Review of a Class of Emerging Contaminants: the Classification, Distribution, Intensity of Consumption, Synthesis Routes, Environmental Effects and Expectation of Pollution Abatement to Organophosphate Flame Retardants (OPFRs). *International Journal of Molecular Sciences*, 20(12), 2874.

Zhang, X., Yan, S., Chen, J., Tyagi, R. D., & Li, J. (2020). Physical, Chemical, and Biological Impact (Hazard) of Hospital Wastewater on Environment: Presence of Pharmaceuticals, Pathogens, and Antibiotic-Resistance Genes. In *Current Developments in Biotechnology and Bioengineering*. Elsevier, Amsterdam (pp. 79–102).

Zheng, F., Zhao, X., Zeng, Z. Wanf, L., Lv, W., Wang, Q., & Xu, G. (2020). Development of a plasma pseudotargeted metabolomics method based on ultra-high-performance liquid chromatography–mass spectrometry. *Nature Protocols* 15, 2519–2537. https://doi.org/10.1038/s41596-020-0341-5