



Food quality and food safety in the 21st century

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Abstract

Food is essential for nourishment and sustenance of life, therefore food safety is a basic human right. But many times, the food that you eat to stay healthy can make you sick. Billions of people in the world are at risk of unsafe food. Many millions become sick while hundreds of thousand die yearly. The food chain starts from farm to fork, however challenges include microbial, chemical, personal and environmental hygiene. Earlier incidents of food quality and food safety were mainly chemical contaminants. More recent outbreaks have been due to microbial agents. To ensure food safety and to prevent foodborne illness, rapid and accurate detection of pathogenic agent is essential. Culture-based tests are being substituted by faster and sensitive culture independent Diagnostics including antigen-based assays and Polymerase Chain Reaction (PCR) panels. Innovative technology such as Nuclear Magnetic Resonance (NMR) coupled with nanoparticles can detect multiple target microbial pathogens DNA or proteins using nucleic acids, antibodies and other biomarkers assays analysis. The food producers, distributors, handlers and vendors bear primary responsibility while consumers must remain vigilant and literate. Government agencies must enforce food safety laws to safeguard public and individual health. The intimate collaboration between all stakeholders will ultimate ensure food safety in 21st century.

Keywords: food safety, sick, foodborne illness, PCR, NMR

Introduction

Food safety is a basic human right

Billions of people in the universe are at risk of unsafe food. Millions of people become sick where as hundreds of thousands die every year because they consume unsafe food. Hence, safe food saves lives. Safe food enhances every individual and population health. Safe food improves economic growth of the region where food safety is practiced and enhanced. Safe and quality food supply depends on both sound science and equitable law enforcement. With technological advances, new regulations must be enacted to protect a continuing supply of food products that are safe and wholesome for health and wellness of people.

As the standards of living improves, contingency over food quality, food safety and potential contaminants will continue to be an important health issue. Consumers demand for quality and safety of products they consume because food act as source of energy and nutrient for sustenance of life. In general, consumers rely on government to ensure all food products not only are safe but are sold as what they claim to contain. For example, a jar of olive oil labeled as 100% virgin olive oil must contain exactly what the label says except the naturally occurring trace elements that are part of olive oil and which cannot be extracted or eliminated completely without destroying the olive oil.

In the 21st century, food safety issues have not waned. Local outbreaks can turn into international emergencies. For example COVID-19 that occurred in Wuhan, China. The current onset of the COVID-19 pandemic has led to an unprecedented crisis all across the globe^[1]. Serious foodborne disease outbreaks have occurred on every continent due to the speed and range of product distribution. In 2011, the

Enteropathogenic Escherichia Coli (EPEC) outbreak in Germany linked to contaminated fenugreek sprouts, where cases were reported in 8 countries in Europe and North America, leading to 53 deaths. The 2011 *E. Coli* outbreak in Germany caused US\$ 1.3 billion in losses for farmers and industries and US\$ 236 million in emergency aid payments to 22 European Union Member States^[2].

Unsafe food poses global health threats. The young, the elderly and the sick are particularly vulnerable. If food supplies are unsecured, population shifts to less healthy diets and consume more 'unsafe foods' - in which chemical, microbiological and other hazards pose health risk, that in turn costs higher healthcare expenditure and drains national wealth^[3]. In light of recurrent food contamination incidents, food safety in the 21st century should expand beyond improving nutritional profile, transparency of ingredients and regulations of unhealthy foods to include regular monitoring, surveillance and enforcement of food products in furtherance of the general public well-being and prevention of foodborne illness^[4].

Major Challenges of food safety

Food safety challenges include 4 major areas, that are

1. **Microbiological safety:** Food by nature is biological. It is capable of supporting the growth of microbes that may be potential source of foodborne diseases. Viruses are more responsible for the majority of foodborne illness, however hospitalizations and deaths associated with foodborne infections are due to bacterial agents. The illness range from mild gastroenteritis to neurologic, hepatic and renal syndromes caused by either toxin from the disease causing microorganisms. Foodborne bacterial agents are the leading cause of severe and fatal foodborne illnesses.

Over 90% of food poisoning illness are caused by species of *Staphylococcus*, *Salmonella*, *Clostridium*, *Compylobacter*, *Listeria* *Vibrio*, *Bacillus* and *E.coli*. For instance, in the US and France, in the last decade of the 20th century, *Salmonella* was the most frequent cause of bacterial foodborne illness accounting for 5700 to 10,200 cases, followed by *Compylobacter* for 2600 to 3500 cases and *Listeria* for 304 cases [5].

2. **Chemical Safety:** Nonfood grade chemical additives, such as colourants and preservatives and contaminants, such as pesticide residues, have been found in foods. Some food samples had higher levels of heavy metals such as lead, cadmium, arsenic, mercury and copper than average food samples, suggesting possible leaching from utensils and inadequate food hygiene.
3. **Personal hygiene:** Poor personal hygiene and sanitation practices of food handlers and preparers pose considerable risk to personal and public health. Simple and routine activities such as thorough hand washing with sanitizer and adequate washing facilities can prevent many foodborne illnesses.
4. **Environmental hygiene:** Inadequate recycling and waste disposal equipment and facilities lead to the accumulation of spoiled and contaminated food. This lead to an increased pest and insect population that can result in risk of food contamination and spoilage. Poor sanitary conditions in the area where foods are processed and prepared contribute to poor food storage and transport as well as selling of unhygienic food.

Major food borne illness

Unsafe food that commonly contain *Clostridium Perfringens*, *Salmonella*, noravirus, cigntaxin etc. hazards include uncooked foods of animal origin, fruits and vegetables contaminated with feces, raw shellfish and industrial pollution [6]. In the comprehensive estimation, the 2015 WHO report not only provides numbers of foodborne illnesses in terms of incidence but also number of deaths and Disability Adjusted Life Years (DALYS) as a major of burden due to foodborne related morbidity and mortality. The DALYS data are based on the metrics established by WHO and are consistent with the global burden of disease project [7]. These foodborne hazards caused an enormous human burden of 33 Millions DALYS with 40% among children younger than 5 year old. With substantial global burden of foodborne diseases and deaths, the impact is most significant among young children living in low income regions where food hygiene and water sanitation are below optimal standards. It should be noted that anti microtrial overuse and misuse in the veterinary and human medicine has been linked to the emergence and spread of resistant bacteria, rendering the treatment of infections diseases ineffective in animals and humans [8].

From a global perspective, most foodborne pathogens and toxins, along with morbidity, mortality and health burden are

depicted in Table 1. A brief detail of their illness is given below:

1. **Bacteria:** *Salmanella*, *Compilobacter* and *Enterohemorrhagic Escherichia coli* (EHEC) are among the most common foodborne pathogens. Symptoms include fever, headache, nausea, vomiting, abdominal pain and diarrhoea. Sources of salmonellosis include egg, poultry and other products of animal origin. Foodborne *Compylobacter* is caused by raw milk, raw or uncooked poultry and drinking water. EHEC are associated with unpasteurized milk, undercooked meat and fresh fruits and vegetables. *Listeria* infection increases the risk of spontaneous abortions and stillbirths. *Listeria* is found in unpasteurized dairy products and various ready-to-eat foods and can grow at refrigeration temperatures. *Vibrio Cholerae* infects people through contaminated water or food. Symptoms include abdominal pain, vomiting and profuse diarrhoea, which may lead to severe dehydration and possibly death. Rice, vegetables, millet gruel and various types of seafood have been implicated in Cholera.
2. **Viruses:** Norovirns infections are characterized by nausea, explosive vomiting, watery diarrhoea and abdominal pain. Food handlers infected with Hepatitis A virus are common source of contamination and spreads typically through raw or uncooked seafood or contaminated raw produce.
3. **Parasites:** Some parasites such as fish-borne trematodes, are only transmitted through food. Other parasites such as *Ascaris*, *Cryptosporidium*, *Entamoeba histolytica* or *Giardia*, enter the food chain via water or soil and can contaminate fresh produce.
4. **Worms:** Cestodes, nematodes, trematodes, and helminths are worms most prevalent in regions where food preparation and storage, personal hygiene, water sanitation and environmental health are not routinely practiced. Even though worm related foodborne illness are not as fatal as virus and bacteria.
5. **Chemical:** Chemical residues used to eradicate or control pests and worms can be an independent risk of foodborne hazards. Mycotoxins, marine toxins, cyanogenic glycosides and poisonous mushrooms are all natural toxins. Staple foods like corn or cereals can contain high levels of mycotoxins (aflatoxin and ochratoxin). Dioxins and polychlorinated biphenyls (PCBs) are byproducts of industrial processes and waste incineration. They are found in the environment and accumulate in animal food chains. Dioxins are highly toxic and can cause reproductive and developmental problems, damage the immune system, interfere with hormones and cause cancer. Heavy metals i.e. lead, cadmium and mercury can cause neurological problem and kidney damage. Contamination by heavy metals in food occurs mainly through environmental pollution of air, water and soil.

Table 1: Foodborne pathogens and their Medical impacts

Foodborne Hazards	Common infectious or toxic agent	Incidence of foodborne illness	Death due to foodborne illness	Total DALYs
Bacteria	<i>Salmonella</i> , <i>Vibrio</i> , <i>E.Coli</i> <i>Shigella</i> , <i>Listeria</i> , <i>Brucella</i> ,	359,747,420	272,554	20,188,792

	<i>Compylobacter</i>			
Virus	<i>Norovirus, Hepatitis A</i>	138,513,782	120,814	3,849,845
Protozoa	<i>Entamoeba, Giardia, Cryptococcus, Toxoplasma</i>	77,462,734	6242	1,311,435
Worms	<i>Cestodes (tapeworms), Nematodes (round worms), Trematodes (Flatworms); Helminths (parasites)</i>	26,063,664	90,261	11,599,735
Chemicals	<i>Aflatoxins, Cyanogenics, Dioxins, Heavy metals</i>	217,632	19,712	908,356

Source: [7]

Diagnostic advances to ensure food safety

Due to the globalization of the world's food trade, food has become a major pathway for human exposure to pathogenic microorganisms responsible for foodborne illness entering at many points along the value chain [9]. Therefore, tracking and detecting microorganisms especially pathogenic bacteria in food back to their resources pose challenges to producer, processor, distributor and consumer of food.

Rapid and accurate detection of pathogen is essential for public health bio-surveillance to prevent foodborne infection and ensure the safety and quality of foods. Relation methods of microbials have improved over time [10, 12]. Generally speaking, culture-based tests are being substituted by faster and more sensitive culture-independent diagnostic tests such as antigen based assays and PCR panels [13].

Non-culture based applications are gaining importance mainly because of their relatively quick results when compared with culture based technologies. Microbial pathogens and contaminants can be detected at relatively low cost in the field because of assay and instrument simplicity. This will ensure higher sampling efficiency of analyte of interest as a result of higher sample measurement volume, detects with near 100% specificity and accuracy as a result of orthogonal measurement [14] of bio-markers with flexibility in sample type such as soil, faces, animal tissue, fruits, water and blood.

NMR-nanotechnology

Nuclear Magnetic Resonance (NMR) nanotechnology platform detects multiple target microbials hybridizing to pathogen's DNA or protein in same the device chamber that runs assays using nucleic acid, antibodies and other biomarkers [15]. Orthogonal confirmatory tests can be achieved via multiple biomarkers of single microbial in same detection device. This raises specificity and accuracy thus serving as both screening and confirming tool at the same time. This instrument increases the sensitivity and specificity of detecting target microorganisms.

PCR based

Polymerase Chain Reaction (PCR) based assay enzyme linked immuno-sorbent assay (ELISA) and instruments rely on extensive enrichment (up to 24 h) to produce enough cells for detection. Following enrichment, the assay requires DNA amplification and detection may take several hours to days. Another commonly utilized technology is based on either standard or real time PCR (qPCR) depending on the instrument and takes up to 3.5 hrs for detection thus unable to perform multiple bio-markers detection.

Government's role to regulate and enforce food safety

New laws and regulations, periodically, must be enacted to further protect a continuing supply of food products that are

safe and wholesome for the health and wellness of people.

In most countries, the overarching goal of having food and drug administration (FDA) or similar agency is to take responsibility for compliance of food safety law to ensure a three-fold aim in protecting public health and safety:

- Inform citizens of nutrition and components of important food products;
- Enforce existing laws and regulations on food industry to ensure supply of safe food products; and
- Investigate and eliminate potential toxic contaminants and prosecute economic fraud via regular monitoring and surveillance on chain of food supply.

The future food safety

The safe food provides basic human necessity. It supports and help in national economy, trade and tourism. Further contributes to nutrition, security and underpins sustainable development. Globalization has immense triggered growing consumer demand for a wider variety of foods, resulting in an increasingly complex and longer global food chain. As the world's population constantly growing, the intensification and industrialization of agriculture and animal production to meet increasing demand for food creates both opportunities and challenges for food safety. Consumers should remain vigilant and literate on food safety issues. FDA and EPA, government agencies, are the legal enforcers to protect public health and safety. They must enforce the law equitably and with firmness. A close collaboration between all the stakeholders should be the goal in achieving a meaningful food safety for every person in global perspective [16].

In summary, food safety, quality and nutrition are closely connected. Unsafe food creates a vicious cycle of disease and malnutrition affecting infants, young children, elderly and the sick. Because food supply chains cross multiple national and regional borders, collaboration between governments, producers, suppliers, distributors and consumers will ultimately ensure food safety in the 21st century.

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