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Food Safety: A Global Perspective

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Summary

The safety of food supply is of global concern and requires the commitment of all countries. A major reason countries import and export food is to satisfy consumer demand. Foodborne illnesses may be linked to the consumption of foods whether grown and manufactured domestically or imported. Global food safety standards are required to ensure that food will not be injurious to health regardless of its origin.

1.1 Introduction

The safety of the food supply greatly influences consumers globally. In developed countries consumers desire, even demand, products year-round regardless of the growing season of those commodities. In order to fulfill those demands, companies source products from throughout the world. The production and processing practices in developing countries may not achieve appropriate safety levels however, placing consumers within that country and throughout the world at risk of illness through export of those commodities. Many developed countries have elaborate standards and guidelines to enhance the safety of food produced domestically. Human health problems arise when best practices are not used throughout the farm to plate continuum, regardless of where the food is produced.

A plethora of factors come into play when attempting to ensure the safety of the food supply. Food safety typically relates to ensuring that food is free of pathogenic microorganisms or chemical contaminates that can negatively impact human health. The safety of the food supply is affected by food security and food fraud. Food security is a social issue in developing countries; in an effort to meet the needs of the country, food that is marginal with respect to safety may be placed into commerce and consumed. Food fraud does not always have food safety implications; however, most cases of adulteration typically involve the addition of illegal substances to food.

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Government agencies strive to ensure the safety of food through national and import monitoring programs to enforce standards. Private organizations lead by the Global Food Safety Initiative, which has five benched-marked audit schemes (Safe Quality Food, British Retail Consortium, Food Safety System Certification, International Featured Standards and CanadaGAP), are accepted internationally and have emerged to bolster consumer confidence in food supply. Ensuring safety and maintaining control of a product means that audits must also be applied to members of the supply chain. Low consumer confidence in the safety of food is not confined to developed or developing countries. For example, China is becoming a major food exporter and in recent years has established three new government agencies: the State Council Food Safety Commission, the Food Safety Risk Evaluation Committee and the Food Safety Standard Examination Committee. The changes were initiated following a litany of domestic (illegally recycled cooking oil) to international (melamine in milk powder and infant formula) food safety scares. All countries continue to develop and implement new laws and regulations, striving to keep abreast of the changing face of the food industry.

1.2 National and global food safety events

In order to gain a perspective of the state of global food safety and the direction in which it is heading, past events that have shaped government and consumer response must be considered. For the most part, many of the major food safety scares are associated with intentionally adulterated or microbiologically contaminated products.

The chemical plasticizer di-(2-ethylhexyl) phthalate (DEHP) was found in an emulsifier used in powdered yogurt mix, fruit jellies and some juices and drinks produced in Taiwan. Products containing the toxic chemical were exported throughout the world. Taiwanese food regulation prohibits the use of DEHP in food.

The Chinese melamine milk scandal occurred in 2007/08, negatively impacting human and domesticated animal health globally. Melamine and other compounds including cyanuric acid were added to the milk to give the appearance of having higher protein content when tested. In China alone, at least six infants died, 800 people were hospitalized and approximately 300,000 were sickened (Gale and Buzby, 2009; Ibens, 2009). In the United States, melamine-tainted wheat gluten and rice protein imported from China and used to make pet food caused at least 17,000 pet illnesses and 4000 dog and cat deaths (FDA, 2009). Following consumption of the contaminated food, animals developed symptoms including lethargy, vomiting, loss of appetite and ultimately death. Kidney damage was apparent in affected animals, the result of the formation of insoluble crystal forming when combining melamine and cyanuric acid.

At the opposite end of the spectrum, food safety perceptions can also be shaped by the popular press and lack of consumer knowledge. In 2012 in the US, reports that 'pink slime' was being added to ground beef resulted in a public outcry followed by United States Department of Agriculture (USDA) statements assuring the public that the product was safe (Stevens, 2012). The product is actually lean finely textured beef (LFTB) that is made from beef trimmings treated with ammonium hydroxide. The LFTB is pink in colour and has a thick viscous texture. Consumers focused only on 'slime' and 'ammonium' and perceived the product to be unsafe. The USDA Food Safety Inspection Service (FSIS) and the US Food and Drug Administration (USFDA) consider ammonium hydroxide as a 'Generally Recognized As Safe' food additive.

The safety of imported products is questioned by consumers throughout the world. Products produced using acceptable production practices in their home country may be rejected by an importing country which has stricter food safety regulations. Regulatory agencies screen imported products to ensure they meet standards of that country. The US imports approximately 80% of all seafood consumed in the US. Fish farming is a growing industry, encompassing commodities from shrimp to tilapia. Integrated fish farming is practised in some countries where, for example, poultry are

raised in structures floating on or over fish pounds. The poultry faeces drop into the water and serve as feed for the fish. The faeces may contain pathogenic bacteria that present a human health risk. Depending on production practices, antibiotics may be included in the water or feed provided to the poultry, which may precipitate the selection of antibiotic-resistant bacteria. The shipments of such farm-raised fish to the US checked by the FDA are frequently contaminated (Buzby *et al.*, 2008; Gale and Buzby, 2009).

Innovative measures are often employed to ensure safety and reduce the likelihood of human illness associated with consumption of a given commodity. In 2012, the USFDA urged restaurants and food outlets to stop selling all fresh, frozen and canned oysters, clams and mussels from South Korea since such products may have been exposed to human faecal waste and contaminated with noro-virus. The shellfish are grown in natural inlets along the southern coast of South Korea. The workers on those fish farms live on boats and were releasing sewage into the production water. In response, South Korea developed floating toilets to be used by workers on the seafood farms. In this instance, the nation's food safety agencies worked with the shellfish industry to develop methods that would improve the safety of the product, preserving the industry and export potential of the product.

1.3 Foodborne illness outbreaks: imports and exports

Depending on the type of foodborne illness outbreak, the emergence of a new food safety risk may be signalled. The large 2011 *Escherichia coli* O104:H4 outbreak that was centred in Germany resulted in more than 4000 illness, over 850 cases of hemolytic uremic syndrome and 54 deaths (Frank *et al.*, 2011). The outbreak was linked to the consumption of fenugreek sprouts; the epidemiological investigation suggested the seeds were contaminated with the pathogen which grew during sprout production. The fact that sprouts were linked to the outbreak was not remarkable. Seed sprout production practices are conducive to the growth of enteric pathogens. The pathogen *E. coli* O104:H4 had only been linked previously to one foodborne outbreak of limited magnitude. This outbreak may represent the emergence of a new foodborne pathogen.

Approximately three decades ago in the US, a large outbreak was associated with the consumption of undercooked ground beef. The causative agent was *E. coli* O157:H7, which had not been previously recognized as a foodborne pathogen. Now *E. coli* O157:H7 is a major food safety concern in the US and globally.

A devastating *Listeria monocytogenes* outbreak occurred in the US in 2011, causing 146 cases and 43 deaths (CDC, 2012). The outbreak was linked to the consumption of cantaloupe, although no previous *L. monocytogenes* outbreaks in the US had resulted from cantaloupe. A clear determination in how the cantaloupe became contaminated was not made. However, the outbreak underscores that a food may become contaminated with a pathogen even although that pathogen may not be traditionally associated with that food.

Consumer interest in the safety of imported foods increases when outbreaks occur, even when those foodborne illness outbreaks are associated with domestically produced commodities. The importation of food continues to increase in the US and other developed countries. In 2009, imports accounted for 17% of the food consumed in the US. In the US approximately 80% of the fish and shellfish consumed is imported, while nearly 34% of fruits and vegetables consumed are imported (USDA ERS, 2012). The continued increase in imports is associated with growing ethnic diversity and consumer preference for a wider selection of food products such as premium coffee, cheeses, processed meats and tropical fruit (USDA ERS, 2012). Tropical products (bananas, cocoa, spices), olive oil and cashew nuts are nearly 100% imported since domestic-produced products is close to 0%. In the US, imports of poultry meat, eggs, milk and pork is low; indeed, only 3% of head lettuce is imported. A similar import pattern has emerged in the European Union (EU) (Jaud *et al.*, 2013).

Seafood, poultry, beef and eggs were the food categories linked to most outbreaks in the US based on analysis of 4638 illness outbreaks between 1998 and 2007 (CSPI, 2009).

In some countries imports account for the majority of food consumed; South Korea imports approximately 70% of its food products. Under these circumstances, the South Korean public is extremely anxious when food safety issues develop in countries from which they import foods. Tens of thousands of concerned South Korean citizens demonstrated when the government reversed a ban on the importation of US beef in 2008. The ban was implemented in 2003 when the US announced it detected the prion responsible for bovine spongiform encephalopathy (BSE) in beef cattle.

A ten-fold increase in the importation of seafood occurred from 1988 to 2007 in South Korea. South Korea imported seafood products from about 80 countries worldwide, with much of that seafood being produced in China (AAFC, 2011; USDA FAS, 2012). The safety of food from China is scrutinized by many countries; South Korean officials found that ink and intestines from a small octopus ('nakji' in Korean) imported from China had levels of the heavy metal cadmium above acceptable standards. These events underscore the scepticism that consumers, regardless of the country, express over the safety of imported foods.

1.4 Regulations impacting food safety

Consumers are constantly seeking new and exciting foods and foods of ethnic origin. Multi-component products, even those that are apparently simple, can have an extremely complicated supply chain. A product such as a snack mix may contain less than 10 main components (almonds, sunflower seeds, coconut, dried apricots, spices, etc.), but these ingredients may be sourced from several different countries. Those components will all have different supply chains from harvest, storage, production and transport. Contamination or adulteration could occur at any step in the supply chain of a component, placing the public at risk. Should a single component, for example dried apricots, be sourced from two countries (e.g. Turkey and Uzbekistan) then the food safety risk increases as production and processing practices in both countries must now be considered. The globalization of the food system now means that a greater number of countries are sources of food products than ever before, placing an even greater burden on the government agencies that are responsible for the inspection of imported foods.

In 2012 the US FDA (FDA, 2012b) inspected 2.3% of imported food. In determining which products to inspect, the US FDA relies on risk-based criteria and data on products and manufacturers with a history of violating US import regulations. A means to highlight food safety problems associated with imported foods is to analyse import refusals. The USDA Economic Research Service analysed FDA food-related import refusals and found that fruits and fruit products, vegetables and vegetable products, and fishery and seafood products accounted for approximately 12%, 21% and 20%, respectively, of total violations (Buzby *et al.*, 2008; Gale and Buzby, 2009). Adulteration or safety violations ranged from less severe (such as an insect in cooked soup) to immediate severe risk (such as botulinum toxin in canned foods). The study included 45,941 adulteration violations, which comprised 15.3% pathogens, 25% chemical and 59.7% other sanitary violations. The vegetables and vegetable products group had the most violations for chemical contamination, while fishery and seafood products had the most violations for pathogen adulteration.

A total of 63% of the pathogen adulteration violations were associated with *Salmonella*, with *Listeria* ranked second at 24.8%. Fishery and seafood products accounted for 67.6% (3007 of 4445) *Salmonella* violations, whereas approximately 50% of violations for *Listeria* were associated with cheese and cheese products. Most of the violations for chemical residues were associated with unregistered pesticide residues than for volatile residues that exceed US tolerance levels. In the US the Environmental Protection Agency (EPA)

licences pesticide products and establishes maximum allowable limits (tolerances) for pesticide residues in food and animal feed. Products that have a poor food safety record will more likely be subject to intensified surveillance, especially if those products originate from a country with a suspect violation record.

Similarly to the US, the EU has strict import standards. Stricter regulations have been shown to hinder the trade in seafood (Anders & Caswell, 2009). Consumer demand for seafood has resulted in a doubling of global seafood trade from 1998 to 2008. Most of the seafood is produced in developing countries, in which producers find it difficult to meet the increasingly stringent regulatory barriers imposed by developed countries. Food import refusals can result in trade deflection, generally to other high-income countries. Such deflection is not necessarily associated with product refused because of potential health violations (Baylis *et al.* 2010). Stricter EU sanitary and phytosanitary (SPS) standards may reduce the number of countries that can export to the EU (Jaud *et al.*, 2013). Meeting the initial costs to comply with the standard is difficult, but more troublesome is the recurring costs associated with sustained traceability, certification or quality inspection. Countries including Iran and Vietnam experience a disproportionate number of notifications (violations associated with imported products) compared to their relatively low import shares. The US, Canada and Norway are large exporters to EU countries, but are subject to relatively few notifications (Jaud *et al.*, 2013). The study by Jaud and her colleagues (2013) suggest that a two-tier distribution is occurring where a small numbers of suppliers dominate with a fringe of marginal suppliers. Although the portfolio of suppliers is increasing, the orders are concentrated to a few suppliers of each commodity. This has the potential to be disastrous should food safety concerns for one or more of those suppliers develop.

International efforts are required to ensure safety of the food supply. Organizations including the World Health Organization (responsible for public health), Food and Agricultural Organization (responsible for food security and some aspects of food safety) and the Codex Alimentarus commission (which supports WHO and FAO by developing standards and guidelines) function at the international level to foster food safety. Countries generally have one or more agencies involved in ensuring the safety of that nation's food supply, for example: the Republic of Korea has the Korea Food and Drug Administration and the Minister for food, agriculture, forestry and fisheries of Korea; China has the General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China, China Food and Drug Administration; Japan has the Ministry of Health, Labor and Welfare and the Food Safety Commission; the United Kingdom has the Food Standards Agency; Canada has the Canadian Food Inspection Agency and Health Canada; and the EU as a whole has the European Food Safety Authority. Each country may have slightly different approaches to food safety and has established different tolerances for agents that, when found in food, may present human health risks. This variability can present significant challenges in the export and import of food.

The Global Food Safety Initiative (GFSI) was developed a decade ago. The GFSI was launched to bolster consumer confidence in the safety of food supply following a number of food safety crises. The GFSI has developed definitions of food safety requirements across the industry and the entire food supply chain. Private auditors can gain GFSI recognition through meeting GFSI benchmarks and being recognized as science-based, contemporary and rigorous. GFSI recognized schemes include Global Red Meat Standard (GRMS), Canada GAP (Good Agricultural Practices) and British Retail Consortium (BRC) Global Standards. Food processors utilize these companies to conduct audits to ensure that best industry practices are being achieved and receive certification. The GFSI benchmarked food safety schemes require food production and manufacturing plants to identify their internal risks to food safety and establish a process to mitigate, reduce and ideally eliminate those risks. A major factor in the non-conformance of companies is

failure to train new employees and failure in testing and training verification. Companies seeking to conduct business in the global market must now meet food safety standards established within GFSI guidance documents. This may be burdensome, especially for companies in developing countries that have limited resources. Tying into these stricture food safety standards are revisions and the updating of national food safety laws.

The FDA Food Safety Modernization Act (FSMA) was signed into law in the US in January 2011. Similar measures aimed at tightening food safety laws have been enacted by other countries, but this discussion will focus on the US FSMA. The law will require development and use of food safety plans, based on the Hazard Analysis and Critical Point Control (HACCP) model, throughout the food industry. The law will impact foreign food suppliers, relying on foreign supplier verification program and third-party certification for imported foods. The importer must verify that a foreign supplier has all controls in place, the same as expected of a domestic supplier. The FDA now has the authority to suspend the registration of a food facility; in essence, to effectively shut down a food facility if foods produced present a reasonable probability of causing illness or death if they are consumed. Under the law, the FDA will also have the task of defining which facilities and foods fall into the high-risk category.

The framework has been established under section 201 of FSMA and the newly created section 421 of the Food Drug and Cosmetic Act. The costs associated with implementation of this type of inspection program are not trivial. A 2012 report released by FDA indicated that costs associated with inspection of domestic high-risk and non-high-risk food facilities was $21,100 and 14,200, respectively, per inspection (FDA, 2012b; http://www.fda.gov/food/guidanceregulation/fsma/ucm315486.htm). The costs increase to $24,800 per inspection of foreign high-risk food facilities. Collectively, the FSMA and other existing laws should increase the safety of food produced in the US for domestic use and export and the safety of imported foods. The FDA has established offices in countries exporting to the US to inspect facilities overseas. The FDA now maintains offices throughout the world including, but not limited to, three offices in China (Beijing, Guangzhou and Shanghai), Italy (Perma), Chile (Santiago), Costa Rica (San Jose), South Africa (Pretoria) and India (Mumbai and New Delhi) (http://www.fda.gov/InternationalPrograms/FDABeyondOurBordersForeignOffices/default.htm).

1.5 China's food safety growing pains

China's food manufacturing sector and growth as a food exporter has increased dramatically in the past decade, presenting significant challenges for China's regulatory agencies. Indeed, Chinese food safety is a significant issue for the Chinese people and the rest of the world. The food safety issues encompass both chemical (melamine) and bacterial (*Salmonella*) hazards affecting the Chinese people and consumers throughout the world. A 2011 report estimated that in China more than 94 million cases of bacterial foodborne illness occur each year, resulting in approximately 3,400,000 hospitalizations and 8500 deaths annually (Mao *et al.*, 2011). China is now the third-largest source of imported food and aquatic products in the US, and a leading exporter of those products around the world (Acheson, 2007; Becker, 2008). This has lead to greater foreign scrutiny of China's food safety and pressure to conform to international standards. The spotlight on China's food safety problem lead to the enactment of the Food Safety Law (FSL) in 2009 by the Chinese government. The Food Safety Law replaced the outdated Food Hygiene Law, but the law is only as good as the measures taken to ensure that it is implemented. Notwithstanding, the FSL contains measures designed to prevent and eliminate future food safety problems. More specifically, the law provides a starting point for a new regulatory scheme governing food safety: increased inspections, mandatory recalls and a risk-based approach to determining foodborne illness threats. The Chinese administrative authorities that have

the responsibility of implementing the FSL now need to be held accountable for enforcement or lack thereof to the public and through the Chinese legal system.

The number of incidents of food contamination and adulteration in Chinese food imports are the main reason why such a focus is placed on the safety of food from China. As indicated previously, China is one of the fastest-growing sources of US food imports; however, less than 1% of the US food supply comes from China. China is a major supplier of fish and seafood (predominantly farm raised), juices and canned fruits and vegetables (Gale and Buzby, 2009). Approximately 60% of US apple juice supply and more than 50% of the garlic supply in 2007 were imported from China. Safety concerns arise as more knowledge of China's production, manufacturing and handling of food becomes available. Crops have been found to contain unacceptable (based on US tolerances) levels of pesticides and heavy metals, and animal products found to contain veterinary drugs. Fresh produce, which is typically maintained in a cold chain from harvest to retailer in the US, may be transported in open trucks, increasing the risk of contamination. Understanding food microbiology will assist in reducing the cross-contamination of commodities during handling. Manufacturing ice from non-potable water and then using that ice to chill fresh fruits and vegetables or seafood can result in cross-contamination of those commodities. Although China has many large modern farms and manufacturing facilities, there also exist millions of small establishments that lack the technical expertise and resources to develop and implement modern practices designed to ensure the safety of food destined for domestic consumption and potentially export.

China has dealt with many scandals concerning domestic and exported food products, but is also increasing measures to ensure the safety and quality of food being imported by China. Notably, in 2012 products produced by Kraft (cream cheese), Nestle (chocolate bars) and Ikea (chocolate almond cake) were destroyed by the Shanghai Quarantine Bureau. In the case of the chocolate almond cake, excessive levels of coliform bacteria were found associated with the product. An increase in these types of actions is likely as the Chinese regulatory authorities seek to improve the safety of domestic and imported foods.

1.6 Food safety and product testing

The safety of imported and exported food is based on food standards and regulatory limits. Global sourcing means that exported products are tested to show compliance and imported products are tested to check compliance. Testing is generally performed to determine biological hazards (parasites, bacteria, viruses or bovine spongiform encephalopathy) or chemical hazards (veterinary drugs, pesticides, natural toxicants or adulterants). Sensitive and rapid test methods are required so that products, particularly those that are highly perishable, can be evaluated and moved into the food supply if deemed safe. Even with a robust toolbox of testing methods, intentional adulterants and new emerging pathogens may fail to be detected. For example, testing designed to determine the presence or absence of a given microbe such as *Escherichia coli* O157:H7 would fail to detect *E. coli* O104:H4. Products contaminated with either pathogen present a human health risk. New laboratory technologies must therefore be developed that are rapid and detect a range of microbial agents (Cowan-Lincoln, 2013).

1.7 Fresh fruits and vegetables safety

The safety of fresh and fresh-cut fruits and vegetables has received considerable attention globally. The FSMA in the US now requires the US FDA to establish science-based minimal standards for the safe production and harvesting of those types of raw fruits and vegetables (e.g. lettuce, tomatoes and cantaloupes) for which standards are necessary to minimize the risk to human health including death. The 'Standards

for growing, harvesting, packing, and holding of produce for human consumption' will focus on microbiological hazards (FDA, 2013b). The reason for this is that illnesses attributed to chemical hazards associated with the consumption of fresh and fresh-cut produce are rare (FDA, Food and Drug Administration, 2013a). Similarly, data show that between 1997 and 2011 there were no Class I recalls of produce associated with physical hazards (FDA, Food and Drug Administration, 2013a) (Class I recalls are initiated when there is a reasonable probability of the product causing serious health problems or death).

The microbial safety of produce is a concern; between 1996 and 2010 approximately 23% of total outbreaks of foodborne illness were produce related. Imported produce and domestic produce were identified as vehicles in these outbreaks. A wide range of products was associated with those outbreaks including green onions, cantaloupe, spinach, blueberries and lettuce. The majority of the outbreaks were however associated with sprouts and leafy greens. Bacterial agents (e.g. *Salmonella, L. monocytogenes* and *E. coli* O157:H7) were associated with 86.5% of outbreaks followed by parasites (11.6%) and viruses (1.9%). Under the FSMA, foreign suppliers are required to meet the same standards as domestic producers. This also includes foreign farms that meet the criteria of 'covered farms' that grow, harvest, pack or hold covered produce for import into the US. Meeting the standards outlined will likely be costly and may limit the ability of some developing countries to comply, impeding exports of fresh fruits and vegetables to the US.

1.8 Conclusions and future outlook

The increase in the breadth and stringency of food safety regulations will only enhance the safety of the food supply if those regulations are enforced. The lack of appropriate infrastructure and well-trained inspectors, particularly in developing countries, will hinder improvements in food safety. Industry and government cooperation, both domestic and international, is key to facing the challenge of food system protection; failure will have a negative effect on human health. As the global integration of the food supply continues to increase, the focus must remain on providing consumers with safe food regardless of its source.

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