

Chapter 1

Emerging Global Food System Risks and Potential Solutions

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Overview

The food system is becoming ever more globally integrated, providing a broader array of foods available all year long than ever before. This adaptive, dynamic system does this very rapidly and at very low cost due to the high efficiency of the food and agriculture supply firms and chains. Globalized, just-in-time and cost-optimized supply chains do

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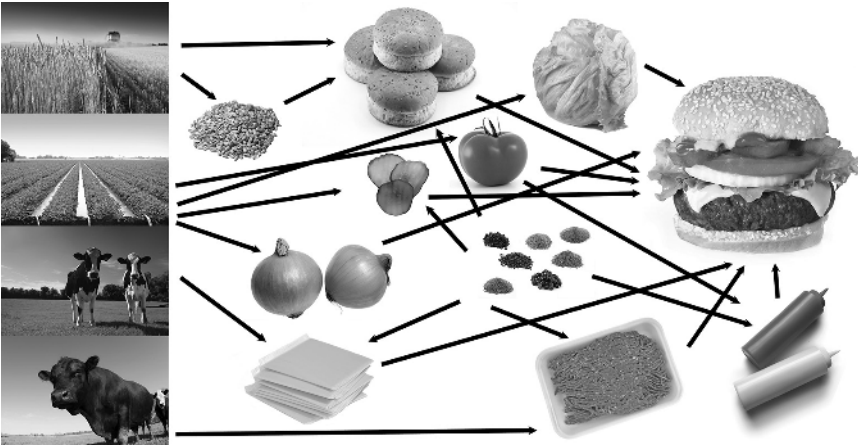


Figure 1.1. A simplified characterization of the supply chain for a cheeseburger. (Copyright 2010 National Center for Food Protection and Defense. All rights reserved.)

not come without concomitant risks. The lengthening of a supply chain and the inclusion of firms of different scales inherently increases the risks associated with that supply chain. Sourcing from a wide range of countries also places a reliance on the food protection (safety and defense) systems of the source country to protect consumers in the country of consumption. One of the challenges of this reliance is that, in some cases, the actual source of the product or ingredient may be difficult for regulators, or in some cases even food-system firms, to discern due to how data are captured and shared in food supply chains. Dynamic import risks and other emerging risks, demonstrate the need for new mitigation strategies to reduce the risk to public health from our globally interdependent food system.

Supply Chain Complexity

The supply chain for even apparently simple items can be much more complicated than it would appear, especially if it is a multicomponent product where the supply chain of each ingredient or component must be considered as well. Figure 1.1 provides a simplified characterization of the supply chain for a quick service restaurant sandwich. The 11 basic components of this item make their way from primary production to consumption through a simplified supply chain that includes

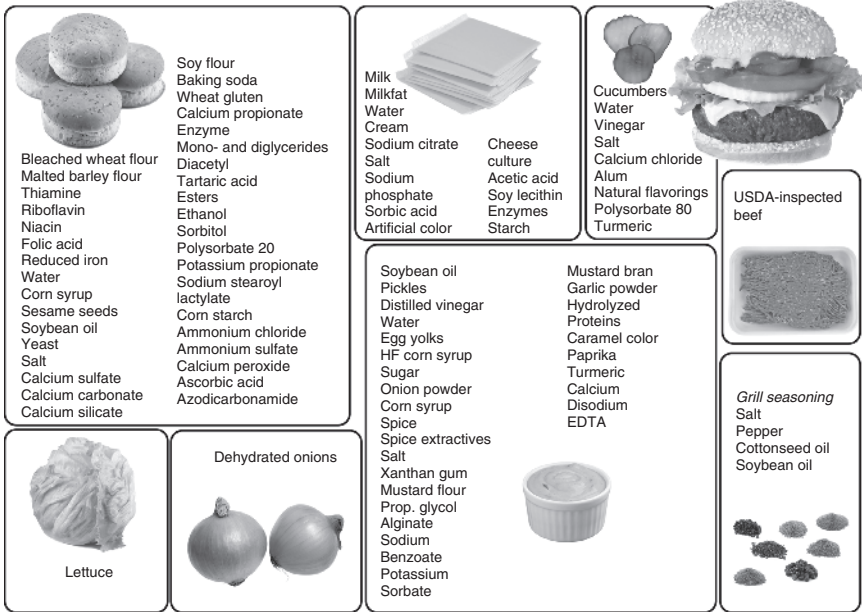


Figure 1.2. All of the ingredients in a McDonald’s Big Mac. (Graphic copyright 2010 National Center for Food Protection and Defense. All rights reserved.)

harvest, storage, production, and retail food service to the consumer, with transportation between each step. Considering this simple system, a contamination that could occur at three, unspecified points in the supply chain for the item represents over 45 000 permutations and combinations of potential contamination scenarios. All of the potential scenarios would have the potential to cause harm, either public health or economic, or in some cases both.

Consider, however, that the actual composition of a cheeseburger, for illustration purposes a Big Mac as per McDonald’s nutritional information, contains all of the ingredients shown in Figure 1.2. Considering the same threat, that the supply chain is contaminated in three locations but no indication of where, means that there are over two million permutations and combinations of potential contamination scenarios. This does not take into account how much more complicated it would become with the inclusion of each of the ingredient’s supply chains. This is one reason why multicomponent foods, which are a rising source of foodborne illness outbreaks, pose a significant challenge during foodborne illness outbreak epidemiology and food

trace-back investigations. While this complexity is obviously important for food safety, it is perhaps more important for food defense as there are many more ingredients that are viable candidates for intentional contamination than are likely to be the vehicle for accidental food safety contamination.

Imports further complicate existing food protection challenges. While only the producer would have the opportunity to know the probable origin of the ingredients in the finished product, looking at where they could come from is enlightening. Choosing just four of the ingredients from Figure 1.2 illustrates this point: imports of beef into the United States in 2010 came from 10 countries (Australia, Canada, Chile, Costa Rica, Honduras, Japan, Mexico, New Zealand, Nicaragua, and Uruguay); imports of tomatoes from 12 countries (Belgium, Canada, China, Costa Rica, Dominican Republic, France, Guatemala, Israel, Mexico, Netherlands, New Zealand, and the United Kingdom); imports of wheat gluten from 17 countries (Australia, Belgium, Canada, China, France, Germany, India, Italy, Kazakhstan, Lithuania, Netherlands, Poland, Sweden, Switzerland, Taiwan, Thailand, and Turkey); and imports of vinegar from 36 countries (Argentina, Australia, Austria, Belgium, Brazil, Cambodia, Canada, Chile, China, Colombia, Dominican Republic, France, Germany, Greece, Honduras, Hong Kong, Israel, Italy, Japan, Jordan, Korea, Lebanon, Mexico, Monaco, Netherlands, Panama, Peru, Philippines, Poland, Portugal, Serbia, South Africa, Spain, Taiwan, Turkey, and the United Kingdom) (US Department of Agriculture Foreign Agricultural Service, 2008). These countries encompass a wide range of food protection system capabilities and challenges.

Increasing Role of Imports

Food and agriculture imports have been rising rapidly, accelerating as early as 2003. In 2003 the total food and agriculture imports to the United States totaled just over \$35 billion. In 2010, that increased to nearly \$82 billion (US Department of Agriculture, 2010). This rate will likely accelerate in the coming years. This is driven by a number of factors, including: increased food and agriculture industries outside the United States; consumer desire for a wide variety of fresh fruits and vegetables; increased consumption of seafood; and many others. While the United States continues to be a net exporter of food and

Table 1.1. The most imported foods and ingredients from selected countries.

Country	Import
Albania	Sage
Azerbaijan	Juices
Bosnia/Herzegovina	Pastry
Cambodia	Honey
Chad	Gums
Georgia	Fruit juice
Haiti	Cocoa beans
Iran	Juices
Kazakhstan	Wheat gluten
Kyrgyzstan	Walnuts
Lebanon	Fruit/nut preparation
Mongolia	Honey
Pakistan	Rice
Sri Lanka	Tea
Sudan	Gums
Syria	Olive oil
Venezuela	Sesame seeds
Yemen	Coffee
Zimbabwe	Sugar

agriculture, there are more food manufacturing firms registered to produce food for United States consumption in FDA's Bioterrorism Registration Database outside the United States (150 000) than in the United States (130 000).

Unusual Sources for Imports

The globalization of the food system results in more countries being sources of food products for the United States than ever before. The countries are not always, however, those that you would expect. Table 1.1 is a selective list of source countries and the foods and ingredients imported most from those countries in 2008 (US Department of Agriculture, 2010). These sources may have food safety and defense systems that are different, either better or worse, than those of the United States. In some cases they also may not be a rational source of

the commodity. At a US Governmental level this is a challenge because the only source of data on country of origin is what is captured through import data collections under the tariff system. For tariff purposes, the country of origin is the one that represents > 50% of the economic value of the item at the border.

As an example of tariff rules, consider how Canada can be identified as the single largest source of cocoa and cocoa preparations for the United States (US Department of Agriculture, 2010), even though there is no cocoa grown in Canada. Since cocoa beans are often further processed outside of the growing country, including Canada, it seems reasonable that the economic value of the cocoa butter, chocolate blocks, or other products coming into the United States could represent > 50% Canadian added value. Less obvious, however, is that Canada is the second largest source of citric acid at 40% of total citric acid imports in 2010, even though there are no citric acid production facilities in Canada. The economic value, for tariff purposes includes all costs: transportation, labor, and packaging. Bulk receipt of a product in Canada that is then blended or ground or otherwise handled and then packed off into smaller unit sizes before being shipped to the United States could end up being assessed as > 50% Canadian economic value, as is evidently the case for citric acid. The tariff system was developed to protect the private sector from unfair business practices, as a result its use as a public health tool to validate the source of materials is of variable utility.

There are other cases where the fact that the country is even a source of imported foods, juices from Iran for example, is itself surprising. There are others where the country is a source of a food or ingredient that does not seem logical, such as fish being the largest import from Kazakhstan whose main agriculture industries, as identified in the Central Intelligence Agency World Fact Book, are wheat, cotton, and livestock.

Examining a specific commodity in detail yields other surprises. Table 1.2 lists all the countries that were sources of shrimp into the United States in 2010 (US International Trade Commission, 2010). While most are obvious sources, such as Vietnam and Thailand, there are some that are somewhat surprising. When shrimp products are included, which includes processed foods, another non-obvious source country like Estonia is added to the list. There are also cases where the import data may reflect trans-shipment or further processing

Table 1.2. Countries that imported shrimp to the United States in 2010.

Argentina	Guyana	Philippines
Australia	Honduras	Portugal
Bangladesh	Hong Kong	Russia
Belize	India	Saudi Arabia
Brazil	Indonesia	Singapore
Canada	Japan	South Africa
Chile	Korea	Spain
China	Madagascar	Sri Lanka
Colombia	Malaysia	St Helena
Costa Rica	Mexico	Suriname
Cote D'ivoire	New Caledonia	Taiwan
Denmark	New Zealand	Thailand
Ecuador	Nicaragua	United Arab Emirates
El Salvador	Nigeria	United Kingdom
Estonia	Pakistan	Venezuela
Gambia	Panama	Vietnam
Guatemala	Peru	

through a country that is not a normal source of the base commodity. For example, several of the countries listed have no significant shrimp aquaculture, whether farmed or wild caught, and are not large food processing countries.

New source countries and supply chains for raw agricultural products, ingredients and processed foods will continue to emerge. Primary agricultural production and value-added food processing are two key ways in which developing nations can build their economy. The economic growth comes both through domestic consumption by raising the living standards of rural populations and by building an export base. Recognition of the benefits of building a food and agriculture industry is why there is so much investment in food and agriculture development by organizations such as the United Nations, US Department of Agriculture, US Agency for International Development, and others. The Gates Foundation has dedicated over \$280 million to find ways of increasing the farm productivity and income to help lift African nations out of poverty. An interesting example, at least from a perceived risk point of view, is the United States investment of \$12 million in Afghanistan to help develop a pomegranate industry. Pomegranate is important because it is one of

the very few crops that can be as profitable as poppy, the source crop for opium, and Afghanistan grown pomegranate are reputed to be among the best in the world. Given the instability in Afghanistan, imported pomegranate juice labeled as “Product of Afghanistan” might face some consumer confidence challenges, both for food safety and food defense. In the face of such concerns, it is important to build the food protection infrastructure in the developing world, both public and private, as their food and agricultural production infrastructure develops. If the food protection infrastructure is not advanced as developing countries are growing their food and agriculture industry, the growth actually may subject consumers to greater food protection risks.

Other Emerging Food Safety Risks

There are a number of other trends which are increasing food safety risks that need to be considered in the context of the global food system. The *Salmonella* Saintpaul outbreak of 2008 associated with fresh produce was an example of novel agent–vehicle combinations. Many of the foodborne illness outbreaks over the past several years have involved new agent and food vehicle combinations. New agent–vehicle combinations present significant challenges for risk assessment and risk management, especially during early outbreak investigation.

Consumers’ desire for more fresh produce and minimally processed or ready to eat foods is another source of emerging risk. In the period 1998–2007 over 684 foodborne illness outbreaks in the United States were associated with produce, only 15% of the total, but they were associated with over 23% of the illnesses (Center for Science in the Public Interest, 2009). The US Department of Agriculture (USDA) estimates that fruit and produce consumption will significantly increase by as much as 8% per capita from 2000 to 2020 (Lin, 2004). Foodborne illness outbreaks associated with produce now represent a larger portion of the total outbreaks than ever due to the combination of increased consumption, the type of produce, and what in-home handling practices are being employed. As initiatives to move to healthier diets that include more fruit, produce, and seafood and less highly processed foods increase, foodborne illness risks may continue to rise.

Industry consolidation and the broad use of common ingredients also pose significant emerging risks. The Peanut Corporation of America (PCA) processed less than 2% of the peanuts harvested in the United States. The recall of its products in 2009 now ranks as the single largest recall in US history. It is at first surprising that PCA could be responsible for a foodborne illness outbreak with at least 714 cases in 46 states, until the ubiquitous use of the contaminated products are considered. As a result, at least 2100 products from 200 companies were recalled. It is, however, just one example of an ingredient that is used broadly from a small number of suppliers. The peanut paste that was PCA's primary product found its way into everything from granola bars to ice cream.

As demonstrated by the Peanut Corporation of America (PCA) outbreak and recall, products can go through an intricate web of distributors and manufacturers, in some cases going through several interim manufacturers before ending up in the final consumer product. The complexity of the path from source, through one or more processors and distributors, into a wide array of final products makes it very difficult to rapidly trace all ingredients to their source or to trace the ingredients to final consumer products. That is why some products were being added to the PCA recall as late as 2010 when the initial recall was announced in early January of 2009. If the common ingredient has an international origin, this becomes even more challenging due to the existing difficulty in just accurately determining the country of origin of imported materials.

Economically Motivated Adulteration

The melamine contamination of wheat gluten that resulted in illness in pets in the United States in 2006–2007 attracted public attention to a long-standing industry problem, economically motivated adulteration. Adulterating a food or ingredient in order to have a lower quality item appear to be of higher quality to make a profit drove some of the earliest food laws. This includes adulteration of wines in ancient Greece to thirteenth century food laws in Germany and France and the Assize of Bread proclamation by King John in 1202. Economically motivated adulteration is a significant and growing problem, driven by globalization, economic opportunity, and low probability and

severity of punishment. A Grocery Manufacturers Association study estimates that an economically motivated adulteration event results in losses on the order of 2–15% of net annual sales for the firm (Grocery Manufacturers Association and Kearney, 2010). In Europe, reports into the Rapid Alert System for Food and Feed identified 256 “food fraud” reports in 2003–2007, and 78 of them were on imported products, the single largest type (Kuiper and Kleter, 2009). For the vast majority of the times this represents no health risk to consumers, other than potentially inferior nutrition. The death of infants in China from infant formula that was basically lacking in nutritional content is an extreme example of this (Gossner *et al.*, 2009). The criminal does not want to make anyone sick; they want to make a profit through repeat business.

The 2007 contamination of over 40 000 tons of sunflower oil sourced from the Ukraine with mineral oil is just one of the more recent and public oil adulteration events (Anon, 2008; Patton, 2008). The intentional misrepresentation of lower value oils as higher value oils occurs frequently enough that the International Olive Oil Council was established in Madrid under the auspices of the United Nations. Established in 1959, the Council’s main purpose is developing standards and supporting analytical testing to verify the type and origin of oils. The 2008 melamine contamination of dairy products, however, is an example of “conventional” economically motivated adulteration going terribly wrong. The perpetrators likely did not realize that melamine could cause illness in children. In response to the 2007 contamination of wheat gluten the US Food and Drug Administration (FDA), USDA and the World Health Organization (WHO) all asserted that melamine at the levels present in food and feed did not pose a human health risk. Those assessments were based on adults, but infants and small children are apparently susceptible to similar crystal formation and necrosis processes that occurred in the pets. As a result of this lack of knowledge, and because of the delay in any public notification or regulatory action, over 280 000 children became ill in China. While the reasons for the delay in public notification and regulatory action are still a source of debate, this unfortunately illustrates the risks posed when a source country is motivated to do something that is not in the best interest of consumers in the United States (or even their own countries). That products with melamine contamination ended up in at least 47 countries (Lin, 2004) illustrates

how economically motivated adulteration represents an imported food safety risk. A risk that is magnified if there is uncertainty in how vigilant the source country is in preventing or reporting intentional acts.

Other Emerging Intentional Threats

While protecting the food system against intentional contamination meant to cause harm has become a broad public concern only since the terrorist attacks of 9/11, the use of food to cause harm has a long history. The earliest well documented use of food as a military weapon is from 590 BC. In the war between Athens and Kirrha of the Amphictyonic League, the Athenian poisoning of stored water with the root of the plant helleborous enabled the Athenians to overrun the city when severe gastrointestinal illness rendered the city defenseless.

The Carthaginian general Maharbal successfully used wine contaminated with mandragora (mandrake) in his battle with tribesmen, as did Julius Caesar in 75 BC in Miletus, as he was able to slaughter his Cilician pirate captors by arranging for wine adulterated with mandragora to be delivered along with the ransom for his release (Dalziel, 2009).

Far more concerning examples of using food as a weapon occurred during World War II. The Japanese Army experimented with the use of various foods for the delivery of several pathogens, including *Bacillus anthracis*, *Shigella* spp, *Vibrio cholerae*, and *Yersinia pestis*. The foods included candies that were dropped by planes over villages, as well as experiments with produce, meat, and fish (Harris, 1992; Moon, 1992). More recently, the most well-known, large-scale intentional contamination event in the United States was the 1987 contamination of salad bars with *S. typhimurium* by members of the Rajneeshee cult in Oregon. The attack, which resulted in 751 confirmed illnesses, was a test run by the cult as they were considering options to change the outcome of an upcoming election. Their plan was to see if they could depress voter turnout enough to enable their candidates to be elected to the county boards in order to allow expansion of their compound. The attack was only understood a year later when members of the cult revealed it during another investigation (Shears, 2010). While they are not all well publicized, there have actually been a fairly large number of intentional instances of food contamination in the past 50 years, as are summarized in reports by Mohtadi and Murshid (2006) and Dalziel (2009).

The prior examples of intentional contamination illustrate that there are cases when the consequences of such acts were considered to be, by the aggressor, acceptable. Emerging information indicates that the range of potential aggressors that would consider poisoning food may be increasing. Disgruntled employees, for example, have always been a concern and there are instances of employees dropping metal or glass into products during production or storage. These acts are intended to cause the company operational and economic harm, and have not, historically, been intent on causing public health harm. There is no fundamental reason, however, that harming others would not be an acceptable choice for some disgruntled employees. The potential for this becomes greater if the disgruntled employee is compromised or influenced by an individual or group that does want to cause significant public health harm. To that aggressor, the disgruntled employee may represent an attack route that reduces his own operational risk in carrying out the attack.

Criminals and criminal organizations represent another emerging risk. Lone actors, such as Shane Ward who left a bag with a claimed, contaminated baby food product in the Morrisons' King's Lynn branch in the United Kingdom, is one example of those who might leverage the food protection concerns to their benefit. While he was arrested, Morrisons still suffered the negative consequences of his hoax as the difficulty in proving the negative, that there was no contamination, forced the firm to remove the implicated products from the shelf in order to protect both consumers and their brand.

Extremist special interest groups have been an ongoing concern for food firms. While they have not conducted any food-system attack with significant public health implications, arson, vandalism, and animal release are already established strategies of groups like the Animal Liberation Front and the Earth Liberation Front. A wide range of other activist groups have specifically targeted production agriculture firms because of their activist view of the various firms' impact on the environment, animal welfare, animal use in general, and other related concerns. If any extremist groups cross over the line to consider intentional contamination of food to be an acceptable means of achieving their aims, then public health risks increase significantly. From a United States import perspective, these risks are perhaps even more concerning as the ability to contaminate a food product may be significantly easier, or pose less operational risk, outside rather than inside the United States.

Post-9/11 state sponsored or condoned terrorist groups have been a focal point for a great deal of the homeland security related investments in prevention, response, and recovery to potential weapons of mass destruction (WMD) events. The 2010 Graham–Talent Commission WMD report card rated the country’s bioterrorism preparedness as F, or failing (Commission on the Prevention of Weapons of Mass Destruction Proliferation and Terrorism, 2010), hardly encouraging given the investments made. A comparatively small amount of that investment has been directed to food and agriculture systems, even though terrorist groups have demonstrated interest in food and agriculture. Such groups could effect potentially catastrophic consequences through the intentional contamination of food, either domestically or overseas for import into the United States. Documents recovered from Tarnak Farms in Afghanistan, an Al-Qaeda training facility, confirm that they had been evaluating food and agriculture system attacks as a means of delivering biological or chemical agents (Associated Press, 2006). While a localized event, the intentional contamination of food at an Australian run commissary for Iraqi police in 2006 resulted in at least 350 casualties (Associated Press, 2006), and also establishes food contamination as an acceptable weapon for some groups. It also confirms that there are individuals or groups who are looking at the food system as an attractive target, depending on their objective. When the potential of looking at food systems as the means of delivering an agent is integrated into understanding how globally integrated food systems function, then import vulnerability comes to the forefront.

The total economic value of food imports, ingredients included, is less than 20% of the total economic value of consumed foods. It is nearly impossible, however, for the vast majority of consumers to go through a normal day without eating something that has been imported. This could range from vitamins, spices, processed seafood, fruit, produce, and a wide range of other ingredients and foods. Every imported ingredient or product must be viewed with both a traditional food safety lens as well as the much more threat-based vantage point of potential intentional acts.

Potential Solutions

Just as is the case for food safety, there is no such thing as zero risk when it comes to food defense. There are, however, things that can be done now to reduce the risk, with new mitigation strategies under

development. Since the private sector controls the food supply chain, mitigation strategies to minimize public health risk will often be private sector solutions, whether it is domestically sourced or imported food products that are being considered. The costs of any mitigation strategy are, as a result, very important. While in the end it is the consumer who bears the burden of any additional costs, incurring new costs could put a firm at a competitive disadvantage if others do not incur the same costs. Firms can be incentivized to implement mitigation strategies above those that their own risk management program justifies if the demonstrated reduction in their overall supply chain risk is either attractive to firms downstream from them in the supply chain, or if it reduces their insurance costs. No firm wants to be the source of a foodborne illness outbreak or wants to be the victim of an attack that results in catastrophic public health harm, but not every risk can be mitigated. In cases where there would be competitive disadvantages for leading firms to incur the cost of a mitigation strategy, then regulations or enforced private sector standards are a means of ensuring that all firms bear the financial burden. When this is done well, such as in Hazard Analysis and Critical Control Points (HACCP) requirements, it protects the public without large and unnecessary costs and complexity for food system firms.

Supply chain verification and ingredient certification are areas where either regulations or industry standards could be effective. Verifying the supply chain and all ingredients from consumer back to the point of primary agricultural production are fairly straightforward concepts, but translating them to either private sector equivalents of the Universal Laboratories seal of approval or regulatory agency validation is a much more difficult task. As illustrated by the PCA recall, food supply chains can be very complicated and usually no one firm in the chain has full knowledge of the chain. Some firms are already working toward total supply chain situational awareness, but doing that across all firms and supply chains is a daunting and expensive task. Data management challenges, ranging from data structure to private sector data protection, interoperability of data systems and cost of implementation are all significant challenges in need of additional focus. Attempts to deal with portions of these challenges are being advanced by iCix (<http://www.icix.com/>) and GFSI (<http://www.mygfsi.com/>), but these are not complete solutions, especially when imported foods are included.

The significant opportunity to use market mechanisms such as insurance to both reduce public health risks and incentivize private sector investment in food system risk reduction strategies faces an ongoing challenge in ensuring that regulatory and nonregulatory mechanisms are positively reinforcing. There are examples of regulatory mechanisms such as “zero tolerance” for the presence of a microbial contaminant in a food system that result in a reduction of surveillance for the specific organism of concern due to the economic consequences of a positive result. Given the limited amount of investment that will be available for reducing import system risks and food defense risks, negatively reinforcing regulatory interventions, like zero tolerance, must be avoided. This is why any step forward with regulations should significantly engage the private sector to avoid potential unanticipated negative outcomes.

Food system surveillance, by both the public and private sector, provides significant opportunities to reduce import risks. In the case of the 2007 melamine contamination of wheat gluten, better public and private surveillance efforts might have avoided the event. If stakeholders had been tracking regulatory changes made by the European Union in 2006 because of issues relating to melamine in imported products, they could have increased their inspection and import surveillance of protein-based products. There may also have been commodity-based indicators that could have alerted stakeholders to increase surveillance. At the time of the contamination, wheat gluten was in short supply and the implicated lot was purchased on the spot market. Also, in the two years leading up to the event, imports of wheat gluten from China had risen sharply without a similar increase in Chinese wheat production. These supply chain indicators could have alerted both the private and public sector to look more closely at protein imports in general and wheat gluten in particular. Under the auspices of the Food Safety Work Group established by US President Obama, a subworking group was launched in January 2010 to look at ways of better identifying potential economically motivated adulteration, with the goal of proactively intervening to mitigate public health risks. The Grocery Manufacturers of America (GMA) initiated efforts in 2009 to help firms develop capabilities to avoid economically motivated adulteration. These efforts are taking a particularly close look at risks of imported products for economically motivated adulteration.

Detection strategies, one of the bedrocks of validating food safety systems, also have a potential role in both bolstering food defense and identifying import risks and economically motivated adulteration risks. Effectively utilizing detection systems for these risks requires different strategies than for conventional microbial or pesticide contaminant detection. While the range of potential agents for intentional contamination to cause public health harm is very large, there are some differences relative to food safety that may enable successful deployment. Unlike the need to find one organism in a milliliter or in 625 grams, intentional contamination will most likely involve much higher concentrations of the agent, as the aggressor either wants to ensure the success of the contamination or wants to maximize profits. At a higher limit of detection, existing, or new, technologies may be effective mitigation strategies.

For both intentional contamination and economically motivated adulteration, nonspecific detection approaches also may be useful. Knowing that something is “wrong” with the product but not knowing what could be very useful. Research by the FDA demonstrated that adding strychnine to certain juice products turned them purple (US Food and Drug Administration’s Food Defense Programs, 2005), a fairly obvious indicator that something is “wrong.” The common practice of checking the conductivity of sugar as a final quality assurance step would also identify a broad range of potential intentional contaminants. Similar research needs to be done across a broader range of threat agents and foods to determine which combinations can be easily picked up by either existing, or slightly modified, quality assurance tests. For example, conductivity tests could also be used to determine if something had been added to bottled water, or if the salt for a salted snack had been diluted. There is significant opportunity to develop new detection strategies to identify that something is “wrong” or to “fingerprint” the product.

Going from nonspecific detection methods, there is also a future role for highly specific new detection systems. If there are some agents or agent–food combinations that represent a significant concern, then the specificity may represent an opportunity for tailoring a technology solution. As one example, research on microfluidic devices or reactive films that are specific to the active sites on botulinum neurotoxin show promise as a strategy for detecting toxins via an in-process, real-time system.

Conclusions

Improving imported food safety and effectively managing emerging risks in the globally integrated food system are both critically important. The current, and as of yet unidentified, emerging risks present new and evolving challenges to food system protection that must be managed effectively to protect public health. Regulations will be an important tool in improving import safety and managing emerging risks, but the solutions are still primarily the responsibility of the private sector. The private sector owns the food system and relies on a sound regulatory framework as the base for protecting their supply chains and their consumers. Both public and private food system stakeholders have to be diligent in protecting the ultimate stakeholders – consumers. Industry and government may bear the direct costs of the implementation of any mitigation strategies, and they also manage the consequences of any food system protection failure. In the end, however, it is the consumer that really pays the price of either successful mitigation strategies or food system protection failures, whether imported or domestically sourced.

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