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Food Safety and ICT Traceability Systems:

Lessons from Japan for Developing Countries

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Abstract

The increasing number of food safety problems occurring worldwide in recent years has heightened consumers' food safety awareness and has caused public distrust of the increasingly complex and globalized food production and trading system. Establishing a food traceability system could improve consumers' confidence and address the documentation requirements required under multinational and bilateral trade agreements. Food traceability systems are therefore becoming critical for the food industry and the public sector, as well as for consumers.

The increased requirements for documentation and reporting systems are taking a toll on developing countries that are hoping to expand their trade in food or break into new markets. Smallholder farmers in particular could be further marginalized from the global food trading system by the burden of the reporting requirements. This paper reviews experiences in using information and communications technology (ICT) to create efficient traceability systems and make information more easily available to consumers.

Case studies from Japan, where the use of ICT in food traceability systems is relatively advanced, reveal lessons for developing countries. The paper examines institutional arrangements, hardware and software requirements, costs of operation, roles of the public and private sectors, and the impacts of two food traceability systems (one for dried shiitake mushrooms, the other for poultry products, both by smallholder farmers). The two case studies show how ICT can help to establish an efficient traceability system and improve consumers' confidence in the products. They also show that collaboration between public and private sectors is a key to success. The traceability systems facilitate improved efficiency in the management of the supply chain. At the same time, in the event of a food safety incident, the source of the problem can be more quickly identified and appropriate action taken. It is expected that traceability systems will be increasingly adopted in food-exporting countries as a strategy to improve competitiveness in the global food market.

JEL Classification: Q17, O31, L66, O13

Contents

1. INTRODUCTION

In recent years, the global food industry has been rocked with scandals from bovine spongiform encephalopathy (BSE, commonly known as mad cow disease) and avian flu scares to melamine-tainted milk. Numerous cases of labeling fraud and fears of deliberate malicious attacks on the food supply make headlines around the world. These cases have increased public wariness regarding food safety in the increasingly complex and globalized food production and trading system. International organizations, governments, and private companies are all facing the necessity of responding to these fears and minimizing further risk to the supply of safe food.

Establishing a food traceability system[1] is one strategy governments and companies can use to win the confidence of consumers and to address the documentation requirements required under multinational and bilateral trade agreements. Clear traceability systems for food are therefore highly beneficial to the food industry and the public sector, as well as to consumers.

The food industry, for its part, has already been developing systems to ensure food safety, including chemical and biological inspection of final products and the introduction of safety control systems, such as Hazard Analysis and Critical Control Point (HACCP),[2] as well as complying to other global standards such as ISO certifications and World Trade Organization (WTO) standards like the Sanitary and Phytosanitary (SPS) measures. These safety control systems are not in themselves traceability systems. However, the implementation of a traceability system can support compliance with safety control system standards. This is because good traceability systems provide reliable product documentation, which is one element required by international safety control standards.

This paper explores the lessons that can be learned from the creation of traceability systems in one of the strictest markets in the world: Japan. Section 2 discusses traceability systems and their effect on exporters from developing countries. Section 3 looks at the evolution of these systems, including the role of governments, buyers, and certification systems, and section 4 goes on to explore how information and communications technology (ICT) is being applied in the creation of Japanese traceability systems. Sections 5 and 6 examine two Japanese case studies, one in Oita Prefecture and the other in Kyoto Prefecture. Finally, section 7 concludes and offers recommendations to developing countries to ensure that they are not marginalized within the global food trading system.

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[1] In this paper, we use the International Organization for Standardization (ISO) 22005:2007 definition of traceability as, "The ability to follow the movement of a feed or food through specified stage(s) of production, processing and distribution." This definition describes the most basic achievement of a traceability system: following the movement of a product as it moves through the food chain "from farmer to fork." It should be noted that (i) this ISO definition is adapted from *Codex Alimentarius (CAC/GL 60-2006)* and (ii) "movement" can relate to the origin of materials, their processing history, or the distribution of the feed or food.

[2] HACCP is a system of quality control management that identifies potential hazards in the food production process and puts into place strict actions that must be taken to prevent the hazards from occurring. Each company's HACCP system is independent and yet must be able to provide data to the next company in the food chain. HACCP is being adopted worldwide under the recommendation of the *Codex Alimentarius* Committee of the United Nations. It has already been mandated in many countries.

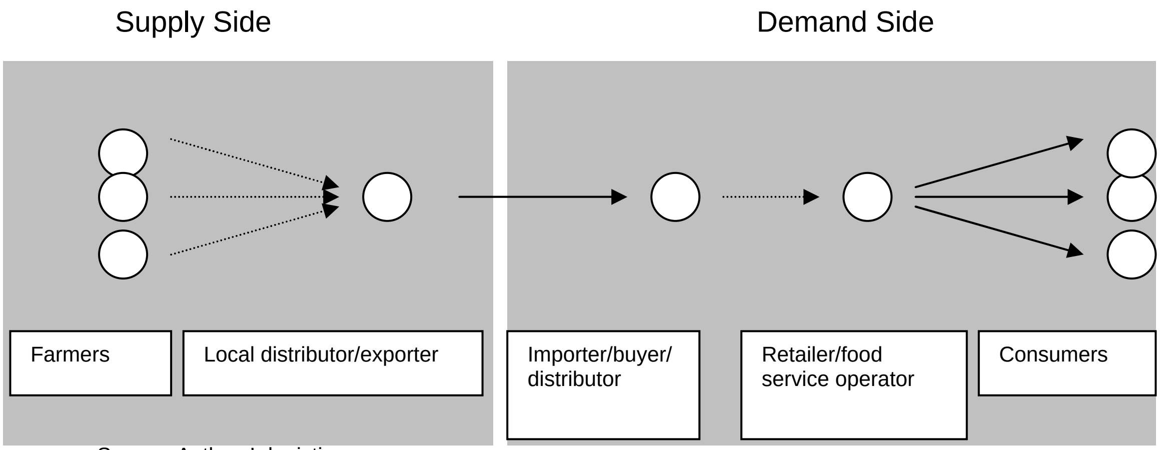
2. TRACEABILITY REQUIREMENTS AND DEVELOPING COUNTRIES

Most food exporters from developing countries would be able to comply with the government-mandated minimum legal documentation requirements on traceability. It is the stricter private requirements of the buyers[3] that are a burden to exporters. These private requirements have developed in response to consumer demands and buyers' assessment of financial risk, and to fulfill the conditions of free trade agreements (FTAs) and the WTO. For example, food for export must conform to various standards such as Good Agricultural Practices (GAP), Good Manufacturing Practices, and HACCP. In cases where value-added food products were produced using raw materials from many sources, the documentation and traceability required by the buyers to ensure food safety and to certify sufficient processing threshold (SPT) under relevant FTA standards can be overwhelming to exporters.

Developing countries aiming to export to the lucrative markets of industrialized countries must have adequate information about buyers' requirements, as well as a solid system for collecting and presenting the necessary information. However, because the food supply chains in developing countries are typically fragmented—relying on many smallholder farmers—and are not necessarily organized into supportive producer associations that can provide the training the food producers would need to create traceability documentation, many of these smallholders will be excluded.

Figure 1 is a simplified depiction of how goods flow in domestic and international food supply chains. Even in the simplest export chains, food products change hands multiple times. As a result, fully traceable documentation of food product movement quickly becomes very complicated. In addition, each buyer may also have their own requirements from suppliers,[4] including slightly different documentation that results in duplicated or time-consuming efforts.

Figure 1: Food Supply Chain



Source: Authors' depiction

[3] "Buyer" refers to a food business operator who buys food products from a supplier. A processor, packer, wholesaler, retailer, or food service operator may act as a customer.

[4] "Supplier" refers to a food business operator who supplies food products to customers. A farmer (or group of farmers), importer, manufacturer, packer, or wholesaler may act as a supplier.

These international trade requirements are already forcing producers who want access to international markets to conform to certifiable standards. However, meeting these standards still does not ensure that a full traceability system—monitoring all movements of the food product—is in place. Standards may require records of certain procedures and processes but they do not necessarily provide a full and reliable accounting of food movement in the supply chain.

Traceability is becoming an increasingly common element in many more complex supply chain management systems, such as those that monitor regulatory compliance, quality control, environmental impact, or food safety. In addition to traceability of movement, these more complex systems may include detailed information on production inputs. These inputs could include vaccinations, agro-chemical use, hygienic conditions of the processing environment, or any other information essential for maintaining the trust of buyers and compliance with relevant regulations.

3. THE EVOLUTION OF TRACEABILITY SYSTEMS

Traceability systems emerged in the mid-1930s in Europe as a way to prove authentic origin of high-value food, such as French champagne. In recent years, such systems have also been called for by increased consumer demand and by public sector action to improve food safety assurance. Capitalizing on the attention to this issue, food marketing strategies have arisen to use traceability systems to support branding. Such strategies can be seen in recent labeling trends, such as organic, fair trade, or low carbon production. As suppliers, buyers, consumers, and governments all respond to the incentives to create food traceability systems, global standards and new technologies are being developed to support efficient and consistent traceability.

3.1 Role of Governmental Regulations

To support international agreements on food trade, such as WTO requirements, national governments are introducing regulations that primarily address the following issues:

- Record-keeping and documentation requirements related to food products
- Labeling, including origin labeling
- Requirements related to product removal, recall, and notification

To fulfill these governmental regulations, it is generally not necessary for companies to implement a thorough traceability system. However, some governmental regulations are stricter than WTO minimum requirements. The European Union (EU) has been the first to put minimum traceability standards into law, as it has under EU Regulation EC 178/2002 Article 18. In addition, for some products, such as seafood, EU regulations require products to come from authorized processors that are in compliance with a variety of EU food safety and traceability regulations as well as international food safety systems such as HACCP. The strict requirements are forcing companies to choose between meeting the strict standards of top export markets and changing to less lucrative foreign or domestic markets.

3.2 Role of Buyers' Requirements

Despite the strict requirements of some governments, the strictest traceability standards are still those imposed by buyers, i.e., trading companies, wholesalers, and retailers. Buyers set their requirements based on what they perceive as demanded by the market, as well as by law. The buyers will demand information or documentation they feel is necessary to minimize the risk of a problem within the food chain. In highly competitive markets, a single food safety incident can ruin the brand name and even the business, and therefore buyers in extremely competitive markets, such as Japan, tend to have extremely strict requirements for their suppliers.

Once buyers have outlined their traceability documentation requirements to the suppliers, there are generally two methods used by buyers to confirm that suppliers have fulfilled the requirements. In the first method, the requirements are privately agreed upon between the individual buyer and seller. In this case, staff from the buyer's company or an auditor hired by the buyer will confirm that the documentation fulfills the agreed upon requirements. In the second method, the buyer requires the supplier to become certified as compliant with an open standard. In this case, suppliers are certified by and then subject to audit by the appropriate certification body. Open standards with traceability requirements include the British Retail Consortium Global Standard, International Food Standard, Safe Quality Food 2000 Code, GlobalGAP General Regulations, and ISO 22000:2005.

In general, the traceability requirements of these certifications are (i) product identification; (ii) recordkeeping for one-step-back, one-step-forward, and internal traceability; and (iii) periodic internal checks of the supplier's business to ensure traceability between the raw material received by the supplier and the finished product. It is important to note that these standards do not specify the exact data that must be collected or the method by which the data is supplied to buyers.

3.3 Certification Systems

In addition to the open standards, there are many other types certification systems such as organic, fair trade, or carbon certification, which are based on ethical or sustainability concerns and require documentation of inputs or production methods. In general, there are three types of certification: first-party, second-party, and third-party certification (Setboonsarng 2008). Each of these types of certification uses different auditing systems.

First-party certification is self-claimed or community-based certification. An individual farmer or group of farmers in a local community will sell a product that they guarantee is, for example, a pesticide-free tomato or free-range poultry. This method relies on consumers having a trusting and usually face-to-face relationship with the farmers or sellers.

Second-party certification is a system in which an intermediary that has a close relationship with the farmers provides consumers with information about the product. Some supermarkets use this system for the organic produce they sell. Second-party certification can be considered to be similar to product branding; the effectiveness of this type of certification relies mainly on the reputation of the trading agent.

Third-party certification entails an impartial third party auditing the production process or product movement to ensure that conditions set out under the standards have been adhered to. With a third-party reviewer, global and international standards can be introduced that will be consistent across borders and throughout complex trading relationships. This type of certification system, however, is generally far more costly than first- or second-party systems.

3.4 Uses of Information and Communications Technology

To lower information costs associated with traceability systems, the use of ICT is being explored. The key processes that ICT can support are: (i) identification of food products, (ii) data input, (iii) data transfer, and (iv) verification. *Identification of food products* requires product labeling to be easily identified at each stage in the supply and processing process. *Data input* requires documentation on processes the products undergo as they move through the supply chain, including locations, dates, times, and temperatures. *Data transfer* requires information sharing among the various food business operators, as well as consumers, auditors, and government inspectors. Finally, *verification* should be done to affirm that claims of products are true, by comparing raw material input volume with processed product output volume or by scientific testing such as DNA or chemical analysis.

The technologies can range in sophistication from simple software on a personal computer, data sharing through mobile phone technology, or an Internet-based data input website, to complex sensors using global positioning system (GPS) technology. Table 1 compares some of the traditional methods of traceability documentation with some new methods utilizing ICT to both collect and input data, as well as to share or output data.

Table 1: Traditional versus ICT Methods of Traceability Documentation

Operations Necessary for Implementation of Traceability System	**Technologies Already Used**	**ICT Technologies Applied Recently**
Identification of food	Stamping with ink	• Printing technology (inkjet printing, affixing printed labels) •
Data input	Handwritten or manual input	• Auto identification technology such as bar codes, two-dimensional bar codes (quick response [QR] codes), or the experimental\radio frequency identification (RFID) • Global positioning system (GPS) • Hand-held sensors to scan and record data
Data transfer	Fax	• Disclosing information to customers through websites • Exchanging data electronically among food business operators
Verification	Onsite visual inspection	• Software that automatically calculates and compares total volumes received and released • Examination technology such as DNA examination

Because traceability requirements can impose a significant burden on the players in the supply chain, the hope is that ICT can make data input more efficient and reliable, thereby lowering the cost of verifying compliance with traceability standards. In addition, the greater ease of data output and data sharing will improve the transparency and reliability of information. These technologies will also allow consumers more access to information about the origin and processing of the products they buy. This greater efficiency and reliability of information, coupled with quicker access to the data through electronic databases and tracking systems, can allow problems in the supply chain to be identified and solved more quickly.

While investing in ICT is expected to ultimately reduce the time and resources associated with paper-based record keeping, there are often high initial investment costs involved in moving from paper-based to electronic record-keeping. Therefore, finding the most appropriate technologies and learning from experience is critical for food business operators and public sector officials in developing countries. Looking at experienced markets such as Japan, which have been experimenting with ICT in traceability systems, may help the producers, suppliers, and governments in developing countries "leapfrog" directly to adoption of the most effective technologies.

4. TRACEABILITY SYSTEMS IN JAPAN

Japan's experience has the potential to provide lessons for other countries because Japan (i) has high standards and strict market requirements, (ii) imports a large volume of food, (iii) has a public that is responsive to food safety issues, (iv) has a production system based on small farms, and (v) uses a high technology traceability system.

Japan's food market is notoriously hard to penetrate, due primarily to the high quality standards required by importers and consumers. Exporters who are able to meet the requirements of the Japanese market are well prepared to compete in other lucrative markets. Moreover, Japan is the biggest food importer in the world, importing more than 60% of its food, increasingly from developing countries. Compliance with Japan's food safety standards and traceability requirements opens the door to increased business opportunities.

However, in the last few years, Japan has faced numerous food safety crises, from avian flu outbreaks to dumplings contaminated with insecticide. To protect consumers, the public sector moved relatively quickly to support food safety systems. As such, the experiences in Japan can effectively provide lessons for developing countries searching for possible models. Moreover, unlike other developed countries where food production is often done on large-scale farms, Japanese farms are generally small, providing experiences that are more applicable to farms in developing countries

The high rate of IT adoption in Japan provides a wide range of examples of ICT support in traceability systems. These examples are more relevant to developing countries than might be expected: despite Japan's high-tech image, food producers there tend to be members of a generation that is less familiar with technology. Introduction of ICT in Japanese food traceability systems has had to take into consideration the level of IT skills among the small-scale rural producers—a challenge also faced by developing countries. The public and private sectors have collaborated in addressing the food safety issues through food traceability systems using ICT. In this regard, Japan provides examples of a possible division of labor between the public and the private sectors.

The next sections will discuss the traceability requirements and the food traceability standards in effect in Japan.

4.1 The Evolution of Japanese Regulations on Food Traceability

Japanese regulations: Despite being a market known for strict food requirements, Japanese law requires a full traceability system only for domestic beef.[5] For other foods, Article 3 of Japan's Food Sanitation Law[6] requests that each operator keep records to identify all their suppliers and customers—a "one-step-back" and "one-step-forward" record. This request is similar to Article 18 of the European Union's EC Regulation 178/2002. However, in Japan this type of record keeping is only recommended and is not compulsory. On the other hand, Japanese regulations do require labeling of the place of origin for fresh food and minimally processed food, not only at retail level but also at wholesale level. However, while origin labeling itself is required, a record-keeping system to verify origin area by providing documentation such as delivery slips and/or invoices is only recommended, not legally required, per Article 3 of the Food Sanitation Law.

Japanese Agricultural Standards (JAS): The JAS system was established in 1950 and is overseen by the Ministry of Agriculture, Forestry and Fisheries (MAFF).[7] One of the main

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[5] The Japanese Diet approved a bill to require traceability records for rice and rice products in April 2009. Record-keeping will become mandatory in late 2010.

[6] Available: http://www.jetro.go.jp/en/market/regulations/pdf/food-e.pdf.

[7] Available: http://www.maff.go.jp/soshiki/syokuhin/hinshitu/e_label/.

components of the JAS system is its compliance certification systems. Products passing inspection in accordance with the JAS requirements are allowed to display the JAS logo. These standards are voluntary.[8]

Originally, the JAS standards were intended to assure general product quality and standardized labeling. However, in the 1990s, MAFF expanded the JAS system to cover specific methods of production. These expanded standards, called Specific JAS, cover: (i) processed meat products (aged ham, sausage, and bacon); (ii) free-range chicken (*Jidoriniku*); (iii) organic foods; and (iv) other products disclosing production history and methods.[9]

The producers and packers who wish to be certified under the Specific JAS are required to maintain records to verify production methods and segregation management. While this is not a full traceability system, it makes for a certain degree of traceability. These standards were created to differentiate high-quality products from common products and are not expected to expand to encompass the entire food market.

4.2 Improving Food Chain Traceability

Government organizations and support services: The government has taken steps to support the development of traceability systems in Japan and in 2003, the Food Safety and Consumer Affairs Bureau was established within the Japanese Ministry of Agriculture, Forestry and Fisheries (MAFF). Although traceability systems are not legally required except for domestic beef, MAFF policy is to encourage food business operators to voluntarily establish traceability systems (MAFF 2004, 2007).

To support this policy, MAFF has provided funding for projects such as developing traceability systems utilizing advanced ICT and formulating a handbook to guide the establishment of traceability systems. This *Handbook for the Introduction of Food Traceability Systems* was created for food business operators and aims to facilitate cooperation between the various operators throughout the food chain (Revision Committee on the Handbook for Introduction of Food Traceability Systems 2007). The handbook covers definitions, basic objectives of traceability, the role each operator should play to establish traceability, and how to proceed with the introduction of a traceability system. It outlines examples of general traceability systems as well as guidelines for specific food items. An English translation has been produced for overseas suppliers.

Audit and certification system: In 2005, a committee was formed by the Food Marketing Research & Information Center (FMRIC) at the request of MAFF to discuss the establishment of national certification systems and auditing standards in order to enhance the effectiveness of Japanese traceability systems. The committee released a proposed standard for food traceability systems in 2006 but in the end a national certification system was not approved. Nevertheless, some local governments have set up their own food safety certification systems that include a traceability requirement. The motivations for creating these local certification systems were diverse. Some were created to help establish a local brand while others were meant to ensure food safety or enhance the reliability of labeling. These systems give a variety of examples of systems in which traceability is a key element (FMRIC 2008).

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[8] Note that certification under JAS is completely voluntary; however, quality-labeling regulations under JAS Law are compulsory.

[9] The JAS for “Products Disclosing Production History” is a standard to certify food business operators who disclose information about the production methods and production history of a product. This can include information about the producers, the place of production, and usage of agrochemicals, fertilizers, feeds, and pharmaceuticals. It has been already established for beef, pork, agricultural products (rice, vegetables, fruits, and whole fresh agricultural products), farmed fish, and several processed foods.

Pilot projects of ICT-based traceability systems: Since 2001, MAFF had been subsidizing the development and introduction of traceability systems utilizing ICT that can be used throughout the food chain (FMRIC, 2006). From 2005 to 2007, MAFF spent one to two billion yen (about 10–20 million US dollars) annually on various pilot projects and studies. Examples of these experiments include (i) *integrated circuit (IC) tags* to reduce the cost of reading and recording the unique ID code of food products at each stage of the food chain, (ii) *handheld devices* to record electric data on farm inputs, processing, and distribution without paper documentation, and (iii) *web-based service technology* to keep and transfer data between server computers through the Internet (MAFF 2006).

Despite the large investment in the creation of these pilot systems, only a few were adopted as viable for commercial use throughout the supply chain, as opposed to adoption by a single operator in the supply chain. One of the biggest challenges to more widespread adoption of the pilot systems is the difficulty in reaching a consensus among operators along the supply chain on what type of system to adopt. One main lesson from the pilot projects is that insufficient time and budget was allocated for consultation among stakeholders in order to form a consensus before they designed the experimental information system. As a result, the experimental pilot projects did not fit the needs of all stakeholders in the chain. While there is no doubt that ICT will be increasingly used in the long term, in the short term, MAFF appears to be focusing on ensuring traceability through conventional paper documents and paper-based systems.

4.3 Diversity of Food Traceability Systems

Traceability systems can be broadly classified into two types: systems implemented by individual operators or businesses, and systems that cover operators at several stages in the supply chain.

In Japan, many types of operators have implemented traceability systems *within* their enterprises. When an individual enterprise implements an internal traceability system, it is usually not a stand-alone system. Rather, operators commonly consider traceability as the basis of a specific or integrated management system. This integrated system may include a quality management system, safety management system, inventory management system, or production history information disclosure system.

However, in order to establish a secure food chain traceability system, it is necessary to ensure consistent standards not only *within* individual organizations, but also *between* food business operators along the supply chain, from upstream to downstream. For traceability with wide-ranging application, it is also desirable to ensure consistency *across* food business operators who are at the same stage of the food supply chain, such as processors or packers. To do this, experience has shown that it is often most efficient for several food business operators to form an organization and work together to create a consistent traceability system.

It is easier to ensure traceability in cases where big purchasing operators deal exclusively and continuously with the same small-scale producers. However, the norms of open market situations are such that supply chains are fragmented with ever-changing relationships between suppliers and buyers. This reality makes it even more critical to create a consistent traceability system able to cover various, changing business relationships within the chain.

Creators of traceability systems in Japan find themselves facing common challenges worldwide: (i) reaching a consensus on a traceability system that will fit the needs of all operators in the chain; (ii) creating a system that is consistent *between* and *across* operators, and not only within an individual operator; and (iii) creating a system that addresses the fragmented nature of supply chains with many small producers and operators as well as the ever-changing relationships within the supply chains.

The two traceability systems profiled in the next sections were introduced as responses to these challenges. The first case study on dried shiitake mushrooms in Oita Prefecture evolved in response to the discovery of fraud in place-of-origin labeling, while the second case study on chicken meat in Kyoto Prefecture was a response to an avian flu outbreak. We will use these case studies to look at how these common challenges in traceability system creation were addressed as well as how ICT was utilized for efficiency.

5. CASE STUDY ONE: DRIED SHIITAKE MUSHROOMS IN OITA PREFECTURE

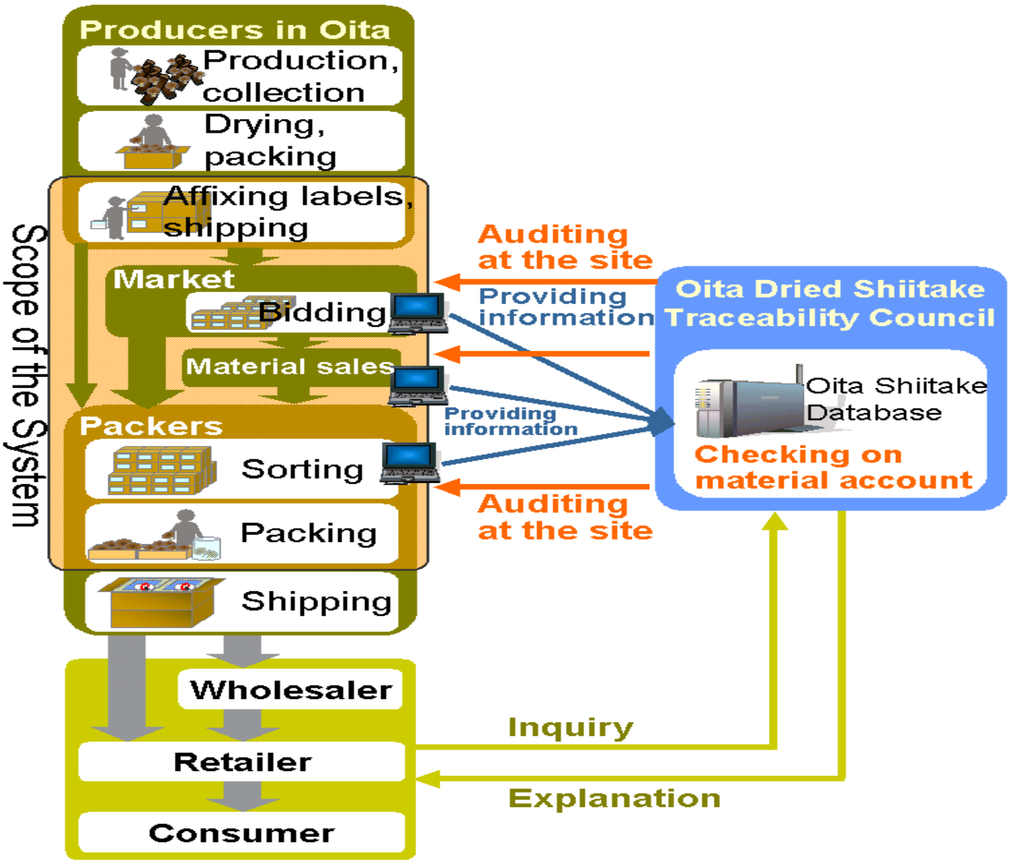
Oita Prefecture produces the largest quantity of dried shiitake mushrooms in Japan. In 2005, Oita’s production was 1,395 tons, about 35% of the total 4,095 tons produced domestically. An additional 8,375 tons were imported in 2005, mainly from the People’s Republic of China. There are over 4,000 dried shiitake producers and over 100 packers in Oita and nearby areas, which conduct transactions in five district markets. Most of the packers procure materials from more than one market. Therefore, there was a need for a traceability system for all the district markets and packers, including packers outside Oita.

Around 2002, place-of-origin labeling fraud was discovered on various food products in Japan, including dried mushrooms. Some dealers were caught selling dried mushrooms produced in the People’s Republic of China as either “domestically produced” or without any labeling of place of origin. Thus, it became necessary to establish a system to ensure the accuracy of labeling by packers in order to gain the trust of purchasing operators and consumers.

Because the system would cover many operators along the chain, it was necessary to get the input from all the major stakeholders. In 2004, the Oita prefectural government set up the Oita Shiitake Traceability System Examining Committee, consisting of representatives of the industry including retailers and consumers. The committee commissioned the Food Marketing Research & Information Center (FMRIC) to design a traceability system for them. The Oita Dried Shiitake Traceability Council was established to implement the system, which became operational in 2006.

As shown in Figure 2, the scope of the traceability system covers from the point at which the materials (dried shiitake mushrooms) are received from the producers to the point at which the materials are sorted and packed. The system is estimated to cover about 20% of all the dried shiitake mushrooms produced in Oita.

Figure 2: Schematic Diagram of Oita Mushroom Traceability System



Source: Food Marketing Research & Information Center.

With the introduction of the traceability system, producers affix shipping labels on the boxes of shiitake for shipping. Producers follow a producer ID system, specifying their names and location code (district/prefecture) on the shipping cards. Most producers had already been doing this, so this requirement did not result in a significant cost increase for them.

At the next step in the chain—the district market— the introduction of the new system required district market staff to input information such as the date, packer ID, weight, and place of origin of the product into the Oita Shiitake Database. The new system required newer models of computers and software to allow the information to be accessible through the Internet (FMRIC 2004). The new hardware and software cost about two million yen (about US$20,000) for each district market and the cost of the new computer operating system was about five million yen (about US$50,000).

5.1 Costs and Benefits of Oita's Production System

To evaluate this system as a model, we look at the major costs incurred by the key stakeholder in the chain—the packers.[10] The packers' incremental costs from introducing the new system are mainly due to the labor costs involved in the system's detailed documentation system, specifically (i) recording internal traceability, such as tracking which materials come from which boxes and what products they are then made into; (ii) setting up the printing machine and recording the necessary data to issue serial numbers for each

[10] Packers are specialized wholesalers who conduct grading, packaging, and primary processing of shiitake mushrooms.

product; (iii) recording the product's weight and quantity and entering it into the Oita Shiitake Database; and (iv) fees due to the Oita Shiitake Traceability Council.

Regarding (i), many operators simply improved existing internal documentation materials, so this step did not incur a large expense. As for (ii) and (iii), it depended on the scale of the operation, but no actual data for these added costs was surveyed. However, it is estimated that operational time increased by 10 to 15 minutes per person per day. Regarding (iv), in addition to the 50,000 yen (US$500) fee per year per operator, the packers also have to pay the Council three yen/kg of Oita dried mushrooms they process. The revenue generated covers the costs and expenses to the Council for auditing the traceability system and managing the database.

The initial costs also involved five million yen (US$50,000) paid entirely by Oita Prefecture for studying and evaluating the pre-traceability system situation and creating a basic plan for a new system. In addition, around 10 million yen (US$100,000), half of which was subsidized by the central government, was spent for developing the database and setting up a server.

In general, in auditing this type of proof-of-origin traceability system, the most time-consuming activity is the verification of changes in the weight or quantity of food products before and after processing or packing. In the Oita shiitake system, however, the main computer program was able to perform these calculations automatically, contributing to efficient auditing.

The benefit of the traceability system was that it increased confidence in the "Made in Oita" label. The price of Oita shiitake had already been rising during the previous years, from 2,532 yen/kg in 2000 to 3,449 yen/kg in 2005. However, in 2007, due mainly to the increasing mistrust of made-in-China food products, demand for domestically produced shiitake increased and the market price for Oita shiitake rose to over 4,000 yen/kg. The district market benefits directly from increases in prices, as it receives a certain percentage of the mushroom selling price as commission. While the Oita traceability system itself did not directly affect prices of shiitake, its creation allowed the Oita shiitake industry to take maximum advantage of the increased demand for domestic mushrooms by providing an authenticated, traceable domestic product.

5.2 Role of the Oita Council

The Oita Dried Shiitake Traceability Council is charged with being the organizational body for a large number of operators in the shiitake food chain. It is supported by the staff in charge of promoting dried shiitake mushroom production at the Oita prefectural government office. The Council represents five district markets and 34 packers (as of March 2007) and has five responsibilities. These are: (i) auditing place-of-origin labeling, (ii) managing the "Oita Shiitake" logo and operator ID number, (iii) training participating operators, (iv) publicity, and (v) reception of inquiries regarding traceability. All of this work is managed exclusively by the Council staff. The following explains each of these responsibilities in more detail (FMRIC 2007).

Auditing place-of-origin labeling: Because building confidence in the place-of-origin labeling is the key function of the Oita traceability system, auditing of the system is critical. To do this, the Council records the packers' purchasing volume data (provided by the district market) with the final product volume data (provided by the packers) and compares the balance once a month. In addition, the volume of inventory held by the packers and the volume of sales among packers are recorded to confirm that all Oita shiitake can be accounted for.

The council sets a certain tolerable percentage of discrepancy between the wholesale markets' reported data and packers' data. As long as results are within that percentage, the operator passes the inspection. If results are not within this range, the Council office questions the operator concerned or visits the operator and checks to be sure there have been no mistakes in the recorded data. Also at least once a year, the Council office staff visit packers and district markets to conduct audits. For packers, they ensure that they have proper forms and documentation for internal traceability that meet the guidelines set for packers and that they keep records (ledgers, packing records, etc.) that are the basis for the amounts provided to the Oita Shiitake Database.

Managing the "Oita Shiitake" logo and operator ID numbers: Under the Oita Shiitake Traceability System, packers affix an "Oita Shiitake" logo sticker to each package. For consumers, this sticker indicates that the product's traceability is ensured through the Oita Shiitake Traceability System and it is therefore an important symbol. The Oita Dried Shiitake Traceability Council oversees the appropriate use of the stickers and logos by the district markets and packers and assigns participating operators with ID numbers that are used on the traceability documentation.

Training participating operators: Successfully tracing the movement of food products between food chain operators relies on each operator fulfilling all the requirements of the traceability system. This includes not only understanding how the overall system works, but also becoming comfortable with the new computer software and data input methods. This is particularly important in an industry such as the Japanese shiitake industry, which involves many smallholder farmers, many of whom are older and may have less experience with ICT. Therefore, training and support of the participating operators is important for maintaining the system. The Oita system is designed in such a way that the majority of the data entry is done by a small number of staff at the packing warehouse or district market. Individual producers, therefore, are not required to invest in ICT and if necessary can still submit their data on paper for market staff to input.

Publicity: Educating consumers and purchasing operators about the Oita Shiitake Traceability System is an essential part of building recognition of the "Made in Oita" brand. The Council uses leaflets and has its own website[11] to provide information about the traceability system, including the names of packers using the system, the scope of the system, and how the inspection system works. The leaflets are also given to the packers to distribute to their clients.

Reception of inquiries: The Council staff is available to handle telephone inquiries about traceability from consumers and traders. The availability of information supports consumer understanding and confidence in the system.

5.3 Conclusions on the Oita Shiitake Traceability System

The Oita Shiitake Traceability System is a successful example of a system that responded to several traceability challenges that will be familiar to food business operators in developing countries:

- Creating a place-of-origin verification system
- Creating a system that involves a large number of smallholder farmers as well as markets and packers up the food chain
- Creating a mechanism or organization that can gather feedback from all stakeholders and plan an appropriate system
- Creating a system that uses technology to increase efficiency with reasonable costs
- Creating a system that uses technology that can be adopted even by those with little ICT experience

[11] Available (Japanese): http://www.oita-shiitake.info/.

- Creating a system that includes ongoing training and publicity, which are the foundation of consumer confidence in place-of-origin labeling

In this case, ICT allowed the farmers to efficiently accomplish the key goal of the system: to record and compare the packers' records of product volumes. Being able to effectively verify that all shiitake volumes were accounted for as they moved through the supply chain allowed the Oita farmers to prove the authenticity of their products. ICT allowed verification that was more efficient and transparent than a wholly paper-based system.

The implementation of the traceability system placed the Oita farmers in a solid position to benefit from the increased demand for domestic mushrooms driven by consumer suspicion of Chinese food products. For a product such as Oita shiitake, which cannot compete directly with Chinese shiitake on price, the traceability system provided the farmers with a way to compete on authenticity, quality, and safety assurance. The Oita case can be seen as a system that required minimal costs and ICT training, and yet supported the product reliability of a large number of small farmers who must compete in a very strict market.

6. CASE STUDY TWO: POULTRY IN KYOTO PREFECTURE

The Kyoto Poultry Traceability System was chosen as a case study because it is an example of a response to a global problem—avian flu—and it is also a system that, unlike the Oita model, heavily involves the farmers themselves with the support of local government. The Kyoto system requires a greater amount of information than the Oita case, which primarily recorded only volumes and movement. It records the kinds of poultry, the date of slaughter, and the method of delivery to the destination. In addition, this system includes an example of a method of sharing traceability data directly with customers.

In 2004, an outbreak of avian flu in Kyoto caused substantial damage to the poultry industry and required better risk management measures to restore consumer confidence in poultry products. In April 2006, producers and distributors of eggs, live poultry, and poultry meat established the Kyoto Egg and Poultry Safety Promotion Council with support from the Kyoto prefectural government.

The Council conducted a consumer survey to identify what information consumers desired. The results showed that 39% of consumers wanted to know the date the poultry was slaughtered, 22% wanted to know the last day of processing, 14% wanted the name of the farm at which the poultry was produced, and 13% wanted information on the feed used. The survey also revealed that consumers were more concerned about the reliability of information than how detailed the information was. The Council then created guidelines for quality management and traceability of eggs and poultry, and created a certification system for Council members, who then implemented a safety management system.

The system targets poultry products that are processed by members of the council and consumed mainly in Kyoto Prefecture. The poultry is raised on farms within nine prefectures: Kyoto, Hyogo, Tottori, Shimane, Okayama, Hiroshima, Tokushima, Kagawa, and Ehime. It is then slaughtered and processed at six poultry handling plants. The products are transported by refrigerated truck to retail stores in Kyoto and Osaka Prefectures (27 locations). Currently, this distribution accounts for about 10 tons per day (six tons of thigh and four tons of breast meat).

6.1 Record Keeping at Each Production Stage

The operators at each stage in the food chain (farming, slaughtering, processing, and retail) determine the lot size and give it an ID number. A lot is typically defined as poultry treated in a single day at a particular site. The site can determine smaller lot sizes if it so desires.

At each stage the operators record essential traceability information such as the ID numbers of the lot as well as the ID numbers of the suppliers and customers of the lot. Each operator not only keeps these records at its site but also supplies an electronic version of the records to a central server maintained by the Council.

Operators at each stage keep records of their production history, as well as inspection data. For example, farms keep records of salmonella inspections,[12] vaccine inoculations, information regarding hygiene control, the introduction of new chicks, feed expenditures, and daily feeding management operations. These records are not made available on the server but are available at the farms if a problem needs to be investigated.

6.2 Costs and Benefits of the Kyoto Poultry Traceability System

To lower costs, the council designed the traceability system in way that would minimize the amount of information that needed to be collected and shared. This was done by carefully planning and defining the information to be collected, through consumer surveys and feedback from the stakeholders.

Costs to slaughter and processing site: The slaughtering and processing sites needed only to acquire a personal computer, a label printer, and a database server as their initial investments. Installing the appropriate software and hardware required funds on the order of 2,000,000 yen (about US$20,000) per site. The running costs at each slaughter and processing site total about 200,000 yen (about US$2,000) per year. These annual costs can be broken down into membership fee of 50,000 yen per year, labels and printing supply costs of 40,000 yen, Internet connection and server maintenance fees of 50,000 yen, and usage of a system developed by Mitsubishi Electric Corporation to stamp certified times and locations on products at 60,000 yen.

Costs to retail store: The initial costs for a retail store were also about 2,000,000 yen, the same as the initial costs for a slaughter and processing site. For small stores, the system can be implemented with only a “relay” label printer. This will provide the label used at the retail level that includes information such as the product identification number, barcode, and receiving date. In this case, initial costs can be limited to 600,000 yen. In addition, the running costs of retail stores include the membership fee of between 20,000 and 50,000 yen, labels and printing supply costs at 40,000 yen, Internet connection and server fees at 50,000 yen, and time and position certification usage fees at 60,000 yen. These running costs can total from 60,000 yen (for those who only install the relay printer and do not transfer data electronically) to 200,000 yen (for complete functionality).

6.3 Ongoing Role of the Council

The Council is promoting the system to attract more businesses to adopt it. Ultimately, the goal is to cover the operators at all stages in the poultry supply chain and all businesses across each stage. The greater the number of operators this system covers, the more reliably it can track the movement of poultry products.

As part of their goal to achieve transparency throughout the entire traceability system, the Council’s system for eggs is already subject to audit and review by third-party inspectors. The Council is planning to subject its poultry system to these same actions.

The successful establishment of a traceability system for Kyoto poultry was a factor in helping to restore consumer confidence in poultry. As the traceability system has been set up to allow consumers to directly access product history information through a website, in December 2007, the site was viewed by businesses about 10 times per day, while views via mobile phone numbered about three to five per day.

[12] Salmonella is a class of bacteria that can cause severe food poisoning in humans. One common way it can be contracted is through raw or undercooked eggs, or through poultry meat that is infected or has not been properly processed.

Feedback to the Council has shown that customers, including consumer cooperatives and catering businesses for schools and hospitals, are satisfied with the system. However, chicken prices have not increased, at least in part due to the fact that there has not been another widespread avian flu outbreak in the area. Thus, products traced through the Kyoto system have not been able to command higher prices than products outside the system. However, with the Kyoto system in place, the participating operators are prepared for any problems within their food chain and will be able to minimize damage to themselves through rapid responses or will be able to benefit from product differentiation (Sasaki 2007).

6.4 Conclusions on the Kyoto Poultry Traceability System

The Kyoto Poultry Traceability System, like the Oita system, is an example of a response to several common challenges:

- Creating a traceability system in response to disease risks within the food supply
- Creating a system that aims to lower the risk of a public health concern
- Determining exactly what information is necessary to be collected and shared
- Creating a system in which ICT costs can be adjusted for the size of the participating business
- Creating methods of sharing information directly with consumers and buyers
- Creating a system that includes ongoing publicity to recruit new participants

Like the Oita shiitake packers, the Kyoto poultry businesses are now prepared for food supply crises. The Kyoto operators have reduced the financial risk to their business from a poultry supply safety incident, such as further outbreaks of avian flu. In contrast to the Oita system, the Kyoto system has more deeply involved the producers in the data collection.

For the Kyoto system, collecting and sharing production history data quickly in order to respond quickly to any disease outbreaks was an important goal of the traceability system. ICT allowed the Kyoto chicken industry to input, access, and share this critical information much more quickly and broadly than a paper-based system could and therefore ICT is a critical element in the efficiency of this traceability system.

As an example of a system that addresses a public health risk, the Kyoto system also shows successful synergy between national government, local government, and private sector. While funding was balanced between the industry and the local government, the Kyoto system has used a variety of ICT, including the Mitsubishi stamp system. Systems such as this, which address public health issues, will demand higher costs than the more simple place-of-origin verification system needed for Oita shiitake. However, it is expected that the investment by both private and public sector to prevent public health crises such as avian flu are worthwhile in the long run.

The Kyoto system also shows examples of how to use simple ICT at low cost—websites and mobile phone sites—to give consumers direct access to product history information.

Finally, the Kyoto Poultry Traceability System gives an example of an effective use of consumer surveys to carefully identify the information required to collect and share in order to build consumer confidence. Without the surveys and planning, time and resources might have been spent collecting unneeded information or crucial information might not have been recorded.

7. LESSONS FOR DEVELOPING COUNTRIES

Traceability has become a key word in the global food industry due to increased incidents of food contamination and false labeling of place of origin or ingredients, resulting in increased public distrust of food safety. With their economic interests at stake, the private and public sectors in developed and developing countries are looking into establishing traceability systems for food supply chains in order to regain consumer and importer confidence and reduce the risk of future problems.

Implementing a traceability system does not, in itself, ensure food safety; it does allow a more rapid and efficient response to food safety problems, enabling quick identification of problem sources and their location in the supply chain. Well-planned traceability systems have been shown to improve efficiency in the management of the supply chain for both the public and private sector. Having reliable information about the movement of food within the supply chain also means that, in the event of a food safety incident, the source of the problem can be more quickly identified and appropriate action taken. Unsafe products can then be pulled out from the market while products traced to safe sources can remain, limiting both the danger to consumers and economic damage to the food industry. Traceability also allows the verification of compliance with labeling regulations, making it an important element for the supplier in obtaining the trust of buyers and consumers. It is expected that traceability systems will be increasingly adopted worldwide.

In reviewing the development of traceability systems in Japan and taking a close look at case studies in Oita and Kyoto Prefectures, we make the following recommendations for developing countries:

- With the global trend of increasingly strict standards and traceability requirements, investment in traceability systems is essential to ensure ongoing access to the markets in the developed world. Establishing traceability systems will help ensure that products not only meet World Trade Organization export requirements but are prepared to meet the requirements of the stricter private sector buyers—requirements that can function as trade barriers to products from developing countries.

- Traceability systems strengthen industries and prepare them to handle future supply chain crises or changes in market dynamics. An efficient traceability system lowers the risk posed by potential accidents or market threats and is therefore an important investment for industries aiming to compete in the global market.

- Traceability systems improve transparency throughout the supply chain and ultimately lower the transaction costs associated with recording, transferring, sharing, and querying information. Transparency and lowered transaction costs encourage sustainable supply chains, which are the foundation of environmentally and socially sustainable production and processing practices.

- Traceability systems gain the confidence of not only international buyers, but also domestic consumers who are increasingly concerned about food safety. Traceability systems can allow for direct communication with the public in the producing and buying countries, a type of communication that is increasingly in demand throughout global markets.

- Traceability systems can improve business efficiency throughout the supply chain by quickly and accurately recording, sharing, and reporting information. This efficiency can ultimately improve profits, a benefit to both domestic industry in developing countries and their international trade partners.

Japan's experience in utilizing information and communications technology (ICT) to make input and output of data more efficient and reliable also provides some broad lessons:

- **Traceability systems help prevent food safety crises and food scandals.** In both case studies in Japan, the traceability systems allowed the industries to strengthen their business and to prevent shocks to the industries from food scandals or crises in the sector. The value and effectiveness of a traceability system becomes clear when there is a food scandal, e.g., false information on labels or avian flu, putting the industry in a crisis situation. The two Japanese industries discussed in this paper have not faced a crisis since the introduction of their traceability systems. However, especially in the Oita case, the introduction of a traceability system allowed the industry to take advantage of market opportunities when consumers became distrustful of products grown overseas. The traceability system strengthened the industry.
- **ICT supports efficient traceability throughout the supply chain.** Creating and running a traceability system requires coordination and agreement among the businesses at all stages of the supply chain. The case studies illustrate that ICT allowed the industries to do something they had not been able to do before: quickly and efficiently share information related to their key concerns. In the case of shiitake mushrooms in Oita, this was related to tracking product volumes in order to verify place of origin. In the case of poultry in Kyoto, it was sharing information on production history. ICT allowed for faster and more efficient sharing of information between different stages of the supply chain than a paper-based system could provide.
- **Cooperation within the industry is essential.** The two case studies showed that for a traceability system to be operational, cooperation among stakeholders in the supply chain was essential. There was a need to first establish a body responsible for gaining agreement and consensus within the supply chain. An association of traders, producers, or processors of a specific food product can often play this coordinating role for all the small stakeholders in all stages of the supply chain. For establishing this coordinating body, public sector involvement was essential. Once established, the public sector role was diminished and the governing body could take on the role of maintaining the system, supported by member fees.
- **Traceability systems must be considered a long-term investment.** The key advantage to using ICT within a traceability system is that it allows information to be digitized for faster utilization, i.e., transfer, share, query, and analysis of data. The initial investment in ICT hardware, software, training, and maintenance can be a considerable cost. However, all indications suggest that ICT-based systems are safer and more reliable than paper-based systems. In this way, not only will transaction costs be reduced through faster transfer of information, but safer systems will lower the risk industries face from supply chain accidents. A safe traceability system can be seen as a worthwhile investment for industries in developing countries that are aiming to compete globally in the long term.
- **Information technology (IT) illiteracy among farmers is not a constraint.** One of the main concerns regarding the use of IT at farm level is that farmers in developing countries are not IT literate. However, lack of IT literacy was not a constraint in Japan even though farmers in rural Japan are generally older and are not necessarily IT literate. With a combination of farmers or representatives of farmers' organizations reporting in paper form and a small number of staff to input the data electronically, an effective traceability system can be established.

- **Public funding is crucial for inclusion of small players.** Experience in Japan shows that large companies often have the resources and motivation to invest in their own internal traceability systems to increase their efficiency and reliability in the market. However, for building systems that involve multiple stages of the supply chain and include smaller suppliers, public funding is crucial. In Japan's case, local and regional governments have often provided the initial support for establishing and testing the systems and producer associations have often provided the coordination among the businesses. One key lesson is that the amount of resources needed to support adequate consultation among stakeholders is often underestimated. This can lead to a lack of consensus among traceability system stakeholders.
- **A well-planned central database influences the cost effectiveness of the system.** Because traceability systems vary depending on the characteristics of the food products and the distribution routes being traced, the scope of a traceability system and its data needs can vary widely. The needs of the industry and its goals should determine the size and structure of the central database. A crucial part of planning a traceability system is carefully researching and agreeing on what data is needed, how it will be inputted, and how to provide the output. In case of export products, traceability information should be made easily available in the major importing and exporting countries of the products.
- **Outreach and education is essential.** Traceability systems are most effective when all business in the supply chain, both vertically and horizontally, participate in the system. The outreach and promotion of the traceability system must be part of the system's maintenance. Promotion not only attracts more participants to the system, which ultimately increases the number of traceable supply chains, but it also educates consumers on the reasons for the sometimes higher price tags of traceable products.

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