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Food Traceability

Summary

Food traceability, at the heart of food safety, essential for a variety of food investigations and a valuable facilitator of global food trade, involves the ability to identify, at any specified stage of the food chain (from production to distribution) from where the food came (one step back) and to where the food went (one step forward), the so-called "one-up, one-down" system (OUOD). This necessitates that each lot of each food material is given an unique identifier which accompanies it and is recorded at all stages of its progress through its food chain. Because multi-ingredient foods may include materials from a variety of food chains and countries, importers may have to rely on the traceability systems of other countries up to the point of import.

This Scientific Information Bulletin attempts to bring together the state of play on traceability legislation or impending legislation or voluntary arrangements across the globe, and to develop improved traceability.

Introduction

The identification of the origin of food and feed ingredients and food sources is of prime importance for the protection of consumers, particularly when products are found to be faulty. Traceability facilitates and precisely targets the recall or withdrawal of foods when necessary; enables consumers to be provided with targeted and accurate information concerning implicated products; and is crucial to the investigation of the causes of food poisoning and other contamination outbreaks. Thus traceability is an indispensible feature of food safety. Long before there was any attempt to legislate for traceability, responsible food manufacturers, in their own enlightened self-interest, operated their own traceability schemes. These were usually based on the concept widely known as "one-up, one-down," (OUOD). The impetus to develop legislation was public and governmental concern in many countries over food poisoning and other contamination outbreaks (including potential bioterrorism), despite all the food safety legislation that existed.

Traceability necessitates that each lot of each food material is given an unique identifier which accompanies it and is recorded at all stages of its progress through its food chain.

Identifiers, hardware and software

There are many approaches for unique identification of food, many of which are in use throughout the world. Current practice often involves combining different relevant data fields such as a Global Trade Identification Number (GTIN) with a handler's production lot or batch number. Other, less used possibilities include serialized GTINs (e.g. sGTIN) or Unique Identification numbers (UID) as used by the United States Department of Defense or a Globally Unique Identification Number (GUID) as used by other manufactured product industries.

Unique codes may be stored, presented and transmitted in a variety of ways including ear tags for livestock, printed human readable data, barcodes, 2D barcodes, electronically via radio frequency identification tags (RFID).

Commercially available hardware and software and solutions providers offer a variety of solutions for recording, storing and retrieving data.

Problems of Traceability

Because multi-ingredient foods may include materials from a variety of food chains and countries, importers may have to rely on the traceability systems (if any) of other countries up to the point of import. This may be particularly difficult in the case of developing countries.

Obvious areas of difficulty are where a received or sold bulk supply is a (sometimes heterogeneous) mixture of lots, or where a bulk supply (such as of grain, coffee, olive oil, rice, and milk from multiple farms) is delivered into bulk containers or silos, or where a received or sold pallet load of containers includes a mixture of lots.

However, the major problem areas are reliance on all business operators to maintain adequate records and internal traceability; and the frustrating slowness when utilising traceability for outbreak investigations. This has given rise to the search for a new food traceability concept that emerged around 2008 and that has potential to revolutionise global food traceability (see below).

The OUOD approach requires food supply chain participants to be capable of identifying, through records maintained by the company, the immediate supplier and customer of an identified food material. Although even the smallest of food businesses (at least in developed countries) typically use some form of accounting system, the normal processes and records related to purchasing, receiving and shipping products are sometimes insufficient to fulfill the OUOD requirement or may be unaccompanied by effective internal traceability or maintenance of the onward integrity of the material identifier.

When investigating suspected food poisoning or other contamination, investigations using the OUOD approach are tedious and time consuming. Naturally, the process is serial, in that investigators must first review documents at the last known supply chain node in order to identify the next node up the chain., Although regulations vary from country to country, these usually permit investigators immediate access to records when on site. Since legal consequences may ensue from any investigation, supply chain participants are typically permitted 24 hours to respond to specific requests for information. Assuming each supply chain participant uses the full 24 hours, it may take days or weeks for investigators to work their way back through the chain(s) to identify the source of contamination. Keeping in mind that investigators are often unsure as to the source of contamination, and as multi-ingredient food products contain materials received from several separate food chains many such investigations must be done simultaneously. When the source of contamination is identified, the process is then used in reverse to identify product for recall. In addition to being tedious and time consuming for investigators, investigations are often unnecessarily disruptive to many businesses along each supply chain investigated and more consumers may be adversely affected in the meantime.

Even if it is assumed that all necessary data are present and error free, it is clear that this OUOD system is not designed to point investigators quickly to likely sources of contamination. Adding real-life complexities related to incomplete, missing or erroneous data simply adds to the time and tediousness of food recall investigations.

Legislation, Impending Legislation and Voluntary Schemes

Global

A Codex document elaborates a set of principles to assist competent authorities in utilising traceability/product tracing as a tool within their food inspection and certification system. This document should be read in conjunction with all relevant Codex texts as well as those adopted by the International Plant Protection Convention (IPPC) and the World Organization for Animal Health (OIE) where appropriate. Recognizing the dual mandate of the Codex Alimentarius, traceability/product tracing is a tool that may be applied, when and as appropriate, within a food inspection and certification system in order to contribute to the protection of consumers against food-borne hazards and deceptive marketing practices and the facilitation of trade on the basis of accurate product description (Codex Alimentarius, 2006).

ISO 22005:2007 provides a standard for traceability in the feed and food chain -- General principles and basic requirements for system design and implementation (ISO 22005:2007).

The Agriculture and Rural Development Department (ARD) of the World Bank in collaboration with infoDev (a global grant program managed by the World Bank to promote innovative projects on the use of information and communication technologies) embarked in an effort to explore and capture the expanding knowledge and use of Information and Communication Technology (ICT) tools in agrarian livelihoods. In November 2011, the World Bank released an electronic Sourcebook (e-Sourcebook) to initiate further investment in this sector. Called "ICT in Agriculture", the e-Sourcebook provides practitioners within and outside of the World Bank Group with lessons learned, guiding principles, and hundreds of examples and case studies on applying information and communication technologies in poor agriculture. It consists of stand-alone modules. Module 12 is "Improving Food Safety and Traceability" (ICT in Agriculture, 2011).

The Produce Traceability Initiative (PTI), sponsored by Canadian Produce Marketing Association, GS1 US, Produce Marketing Association and United Fresh Produce Association, is designed to help the produce industry maximize the effectiveness of current traceback procedures, while developing a standardized industry approach to enhance the speed and efficiency of traceability systems for the future (Porter et al., 2011). The PTI has a bold vision which outlines a course of action to achieve supply chain-wide adoption of electronic traceability of every case of produce by the year 2012. The main thrust of PTI has been standardization of data structures and presentation of data on cases and pallets of produce. PTI is described by the produce industry as, " … designed to help the industry maximize the effectiveness of current trace back procedures, while developing a standardized industry approach to enhance the speed and efficiency of traceability systems for the future" (PTI, 2011).

PTI has made great strides in developing data structure and presentation standards for the produce industry; however, PTI remains rooted in the OUOD approach. Therefore, benefits from PTI are more likely to be reduction in data errors and perhaps greater efficiency by supply chain participants in collection and dissemination of traceability data. However, since legal consequences of such investigations remain, it is possible that the time saved may ultimately be consumed internally by company management and/or legal counsel rather than contributing to any acceleration of investigations and recalls. Additionally, it is questionable whether PTI can or will be more widely adopted by other segments of the food industry.

The Global Traceability Standard (GTS) is promulgated by GS1, an international not-for-profit association with member organisations in over 100 countries. GTS makes traceability systems possible on a global scale, all along the supply chain, no matter how many companies are involved or how many borders are crossed, no matter what technologies are used.

National Activities

Information is given below on the situation in some selected countries. Information on other countries is given in McEntire et al., 2010.

Argentina and Brazil

Because European Union auditors are closely monitoring traceability performance in Argentina and Brazil, agricultural officials in both nations are taking steps to align their traceability systems with EU standards (see below) in hopes of reducing inspection visits. For the same reason, a non-GMO traceability system is in operation.
The Patagonia region of southern Argentina is upgrading its fruit traceability system as part of a GlobalGAP benchmarking program called Patagonia Traces. The region's producers as well as the federal and state agriculture ministries are working with GlobalGAP advisors in order to become certified and position more of their products in the display cases of major European food retailers. (Lewis, 2008).

Australia

GS1 Australia has joined forces with Efficient Consumer Response Australasia (ECRA) - supported by the Australian Food and Grocery Council (AFGC) - the Liquor Merchants

Association of Australia, the Food Service Suppliers Association of Australia, key government agencies and departments and key suppliers and retailers from the grocery, liquor and healthcare sectors to establish a portal for all product recalls and withdrawals. In order for accurate and complete product recalls to be a reality, not only does industry need a common platform for the accurate communication of recall information to government, industry and consumers, but also business need to be able to accurately keep and access manufacturing and distribution records. (Australia GS1, 2010)

Canada

The vision is for a secure National Agriculture and Food Traceability System (NAFTS) to better serve citizens, industry and government. The system will provide timely, accurate and relevant traceability information to enhance emergency management, market access, industry competitiveness and consumer confidence. Recognizing industry's leadership and foresight in building the foundation for animal traceability, in 2006, federal, provincial and territorial agriculture ministers committed to phasing-in a NAFTS, beginning with livestock and poultry.

A national livestock traceability system is based on three pillars: animal identification; premises identification; and animal movement.

An Industry-Government Advisory Committee (IGAC) was established to lead the development and implementation of the livestock and poultry components of a NAFTS. The IGAC is comprised of 22 industry members and another 15 representing federal, provincial and territorial governments.

Many livestock sectors have solid foundations for traceability. For example, animal identification is already mandatory in the cattle, bison and sheep sectors, and is regulated by the federal government; other sectors, such as swine and poultry, have independently developed systems for collecting traceability information.

Industry and governments recognize the challenges associated with building a national traceability system, such as costs, confidentiality, liability and compliance, but they are committed to working together through IGAC to address these challenges (Canadian Traceability).

China

'China is embracing the "Internet of Things" (IoT) technology as part of an effort to address thorny food security issues', a government official said. 'A pilot program will include the establishment of a cloud computing center in Shanghai's Jinshan district to ensure food traceability', Li Bin, director of the Ministry of Industry and Information Technology's (MIIT) information center, told China Daily. This means tracing food or ingredients across the partially or entirely reconstructed supply chain, so that recalls can be issued when quality problems arise", Li said on the sidelines of IoT China 2011 Conference and Exhibition in Shanghai. 'It also allows real-time detection of animals, for example during outbreaks of contagious disease, for control, survey and prevention', Li added. (Anon, 2011). (See also Liu, 2012).

European Union

Regulation No 178/2002, which applies in all EU Member States, Article 3 (15) defines:

> 'traceability' means the ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution.

Article 18 is concerned with traceability and states

1. The traceability of food, feed, food-producing animals, and any other substance intended to be, or expected to be, incorporated into a food or feed shall be established at all stages of production, processing and distribution.

2. Food and feed business operators shall be able to identify any person from whom they have been supplied with a food, a feed, a food-producing animal, or any substance intended to be, or expected to be, incorporated into a food or feed. To this end, such operators shall have in place systems and procedures which allow for this information to be made available to the competent authorities on demand.

3. Food and feed business operators shall have in place systems and procedures to identify the other businesses to which their products have been supplied. This information shall be made available to the competent authorities on demand.

4. Food or feed which is placed on the market or is likely to be placed on the market in the Community shall be adequately labelled or identified to facilitate its traceability, through relevant documentation or information in accordance with the relevant requirements of more specific provisions.

5. Provisions for the purpose of applying the requirements of this Article in respect of specific sectors may be adopted in accordance with the procedure laid down in Article 58(2).

These requirements are supported by the the EU Rapid Alert System for Food and Feed (RASFF) which was put in place to provide food and feed control authorities with an effective tool to exchange information about measures taken responding to serious risks detected in relation to food or feed. This exchange of information helps Member States to act more rapidly and in a coordinated manner in response to a health threat caused by food or feed.

India

Public recalls of food products due to food safety concerns are comparatively rare in India, but with the growing capability of the FSSAI (Food Safety and Standards Authority of India) and with the development of branded food products they are becoming common tools to protect customers when things go wrong with a food production process.

"India is rather advanced in the food traceability area and has implemented various tracking and tracing systems in its food industry such as the GrapeNet software used to provide traceability for the table grapes exported from India to European Union. With the Indian food industry projected to grow by $100 billion to $300 billion by 2015 according to a report by FICCI (Federation of Indian Chambers of Commerce and Industry) - Technopak, the Government of India is focussed on enhancing the competitiveness of the food processing industry for both, domestic and international markets. India is definitely well-positioned for more advancement in food traceability over the next several years," said Andrew Tay, APAC (Asia Pacific) president, Zebra Technologies.(More, 2011; Buiji, 2012).

Japan

The Japanese Government has issued a revised updated 2007 version of its "Handbook for Introduction of Food Traceability Systems: Guidelines for Food Traceability". (See also Nanseki, 2008).

Korea

Korea introduced a full beef traceability system in 2008, in the wake of the BSE outbreak (ICT in Agriculture, 2011).

South Africa

A research project (Olivier et al, 2006) has reached the following conclusions:

> Based on the research, including numerous interviews with key stakeholders and experts in the industry, the following conclusions can be deduced:
>
> - Serious information fragmentation since deregulation of the industry in the previous decade, as well as the need to manage costs very carefully in a highly competitive market, created the need for effective access to information of the whole supply chain and all activities.
> - Legal and trade-related traceability pressures require the SA fruit export industry to have automated traceability in place, based on global procedures and standards.
> - The business need for greater efficiency benefits in the SA fruit export industry requires automation of the industry's supply chains based on global procedures and standards.
> - Already developed and tested technologies in the consumer packaged goods industry, that will provide automated traceability and significant efficiency benefits, are available for implementation in the SA fruit export industry.
> - The SA fruit export industry will have a competitive advantage over its southern hemisphere competitors by being an early adopter of these global standards and technologies.
> - Enough cohesion, willing participants and supportive thinking seem to exist in the previously regulated deciduous and citrus environments to create the necessary critical mass for the implementation of these global standards and technologies.
>
> Hence, given the need for effective access to integrated information, automated traceability, the need for efficiency benefits through automated supply chains, available technologies based on global standards and procedures, the opportunity to gain a competitive advantage over southern hemisphere competitors, and enough cohesion,

willing participants and supportive thinking, it is concluded that more effective access to information and automated traceability are feasible for the SA fruit export industry.

USA

After the 2001 terrorist attacks, The US Bioterrorism Act (2001,H.R. 3448) mandated a traceability system whereby:

- Food processors with between 11-499 full-time employees had until June 9, 2006 to comply (less than 10 full-time employees had until December 11, 2006). According to the ruling, upon an FDA request, they had 24 hours to produce the following information or be subject to civil and/or criminal penalties:
- Identify the immediate non-transporter previous sources, whether foreign or domestic, of all foods received, including lot or code number or other identifier
- Identify the immediate non-transporter subsequent recipients of all foods released, including lot or code number or other identifier
- Identify the specific source of each ingredient that was used to make every lot of finished product.

In 2004, the US Department of Agriculture published “Agricultural Economic Report Number 830 (2004). Traceability in the U.S. Food Supply: Economic Theory and Industry Studies.

The 2011 Food Modernization and Safety Act (FMSA, 2011. H.R. 2751) includes provisions to expand authority of the United States Food and Drug Administration (FDA) to, among other things, initiate mandatory food recalls and establishing a food product tracing system. Establishment of the food product tracing system is to involve development of a plan based on pilot studies and stakeholder recommendations. FDA has commissioned the Institute of Food Technologists (IFT) to execute traceability pilot studies, which are currently ongoing.

Given the timing provided to execute pilots and specific constraints written into the FMSA, it is unlikely that the FDA pilot studies being conducted by IFT will result in any immediate fundamental shift away from the OUOD approach, and like PTI, will likely focus on identification of common “Key Data Elements” (KDEs) and data format standardization.

IFT has issued two reports for FDA on traceability: one on technical aspects (McEntire et al., 2011) and the other on costs and implications (Meijia et al., 2011)

On August 9, 2011, USDA issued a proposed rule to establish general regulations for improving the traceability of U.S. livestock moving interstate when animal disease events take place (USDA, 2011). Under the proposed rule, unless specifically exempted, livestock moved interstate would have to be officially identified and accompanied by an interstate certificate of veterinary inspection or other documentation, such as owner-shipper statements or brand certificates. The proposed rule encourages the use of low-cost technology and specifies approved forms of official identification for each species, such as metal eartags for cattle. However, recognizing the importance and prevalence of other identifications in certain regions, shipping and receiving states or tribes are permitted to agree upon alternative forms of identification such as brands or tattoos.

Future of Food Traceability – Critical Tracking Events

Efforts to improve food traceability typically identify two major goals, namely speed and accuracy. Standardisation will likely improve accuracy, but will not do much to improve speed. Speed and accuracy are both necessary to realize benefits from any food traceability system in terms of illness, lives, waste and inventory control. The OUOD approach, regardless of data standardization is simply not capable of providing the speed that will be required by the industry or regulators.

The Critical Tracking Event (CTE) concept is becoming widely accepted as the path to a next generation fast and effective food traceability system (McEntire et al., 2010). The CTE approach is a bottom-up approach that is inherently secure in terms of data ownership, data access and proprietary information protection. The CTE approach recognizes that each operator knows their own operations best and provides complete latitude as to how to collect CTE traceability data. The CTE approach shifts focus from the food product itself to the events that manipulate the product in the supply chain. As each operator handles a food product (harvests, creates, receives, mingles, aggregates, palletizes, depalletizes, relocates, ships, etc.) its actions are viewed as events that occur at a specific locations, dates and times. Some of these events are critical to the ultimate traceability of the product. Therefore, those events are deemed to be "critical tracking events." Since a CTE is essential to ultimately tracking the item in the supply chain, CTE traceability requires a commitment from operators to collect, store and make retrievable, CTE data from every CTE within their operation.

The modern concepts and technologies associated with relational distributed data provide confidence that the CTE model will be much more effective in terms of speed and accuracy. Unlike other approaches that are mired in exhaustive data field identification and standardization, the CTE approach requires very little data, none of which need be descriptive in any way of the product.

Since the goal of the food traceability system is to connect investigators with the source of contamination as quickly as possible, there is little value in collecting large amounts of even standardized data from every node in the supply chain when only a few or even none of the nodes may be of actual interest to the investigation. Rather, it would be preferable to skip nodes that are not interesting to the investigation, saving precious time for investigators as well as time and angst for many food businesses. This ability of the CTE approach to quickly and effortlessly elucidate the actual supply chain through CTEs is the major benefit over OUOD based approaches regardless of data standardization. Additionally, once the source of contamination is identified, the CTE based food traceability system is just as capable of trace forward as trace back, which means that rapid, targeted and accurate food product recalls will be possible.

The IFT's current working definition of a critical tracking event is

> A CTE is any occurrence involving an item at a specific location and time associated with collection and storage of data useful for associating the item (or related items) to the specific occurrence at a later time and is determined to be necessary for identifying the actual path of an item through the supply chain.

When applying this definition, it is easy to see that the many important and often proprietary business process data are not necessary to achieve traceability with CTEs. Basic handling/transfer CTEs require the minimum amount of data, which includes a code to identify the item, a code to identify the particular CTE (e.g. "received at ABC Co. at door #2") and a date and time stamp. Transformative CTEs (mixing, repacking, etc.) require additional information to link the inbound and outbound product-codes.

Under the CTE approach, each operator would determine how best to collect and store data. Some might be able to maintain a CTE Server on-site. Smaller businesses might choose to house CTE data at a third-party (cloud) based service provider. Regardless, CTE data remain the property of and under the direct control of the business generating CTE data. The CTE concept is summarized in Figure 1.

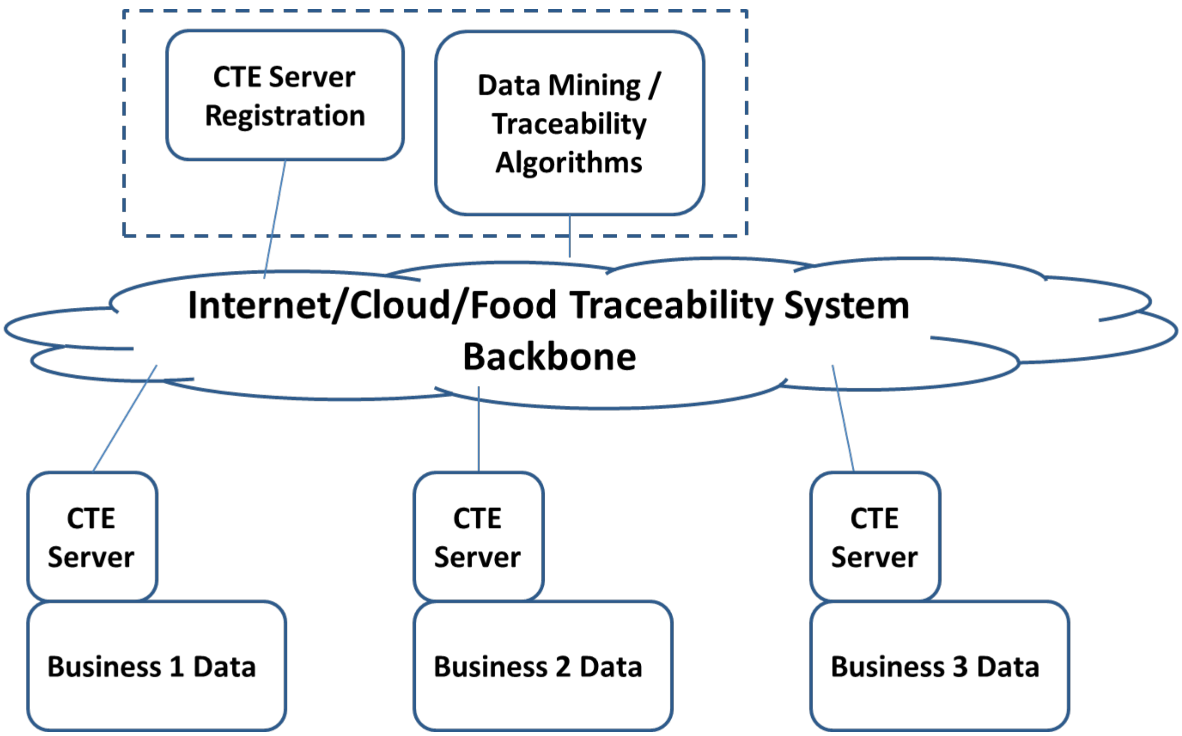

Figure 1--Conceptual diagram of an intergrated, flexible, scalable global food traceability system based on distributed Critical Tracking Event data.

When an outbreak occurs, investigators would be able to query the CTE traceability system by asking, "who has seen item code XYZ?" CTE servers might first alert a company that an appropriate authority has made a formal request. The company could then review the request and authorize a response. The initial response could be minimal in terms of "no" (the item was never seen by our CTEs), or "yes" (the item was seen at these locations at these dates and times). Transformative CTEs would provide the link between products and ingredients. At this point, investigators would be able to clearly visualize the supply chain for the item in terms of locations, dates and times. Assuming other investigations are on-going, there may be nodes that are common to separate investigations (e.g., sprouts from a deli sandwich and sprouts from a restaurant salad bar). In such cases, investigators would be drawn directly to the point of convergence rather than working their way backwards through a cumbersome OUOD system.

Companies may choose to use or not use existing product codes or coding schemes. The CTE traceability approach simply requires product codes that are globally unique (Welt, 2008). Since many current industry coding schemes use qualitative information as part of the code (e.g., PTI combines UPC/GTIN with lot numbers) and since proprietary information may be gleaned from codes with meaningful business data, it is recommended that codes expose no valuable information themselves, but rather point to relevant data for retrieval by properly authorized personnel. For the case of PTI codes with exposed lot number information, someone might be able to glean competitor production rate and/or volume by analyzing rates of changes of lot numbers in product codes. This can be avoided by associating the CTE traceability code to appropriate lot numbers within the enterprise database. Identifying the lot associated with a particular item would be a matter of a simple database query and can be done by appropriately authorized personnel.

Implementation of CTE traceability does not interfere with any existing business processes. However, CTEs require a commitment by operators to collect, store and make available for retrieval a minimal set of data that is inherently secure through abstraction, separation and restricted accessibility. Operators can choose the most appropriate manner to collect data from manual entry to sophisticated automated scanners. Once CTE data are captured and available for query, investigators will no longer need to stop at each node in the supply chain in order to learn where to go next. CTE based traceability promises to greatly accelerate the rate of trace back investigations as well as the precision and speed of recalls.

Conclusion

Food traceability based upon OUOD is not likely ever to satisfy speed requirements necessary for rapid and precise food recalls. A relatively new food traceability concept known as Critical Tracking Events simplifies data collection and standardization while providing for extremely rapid supply chain elucidation during trace back investigations as well as rapid outbreak source identification and precise food recalls.

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