

# Current Status and Future Development Proposal for China's Agricultural Product Quality and Safety Traceability System

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**Abstract:** Tracing the quality and safety of agricultural products by labeling them with relevant information at each stage of production is an important way to identify authorities responsible for agricultural product supervision and management from the production stage to the market. The development of a system to trace the quality and safety of agricultural products is of great significance to ensure food safety from farm to table and to promote agricultural modernization in a country. This paper first summarizes the history, successful experiences, and learnings of developed countries and regions, such as the European Union and the United States, in terms of the development of traceability systems for agricultural products' quality and safety. Next, the development of the Chinese agricultural products' traceability system, established in 2000, is analyzed in detail in terms of four aspects: laws and regulations, standards and codes, information systems and platforms, and key technologies. Finally, based on international development trends and the relevant national planning and requirements of the Chinese central government, this paper highlights four key objectives and three policy recommendations for the future development of China's agricultural products' quality and safety traceability system.

**Key words:** agricultural products; quality and safety; traceability system; current situation of development; development suggestion

## 1 Introduction

Since the 1980s, there have been several food quality and safety accidents involving agricultural products, such as the infected beef causing the human version of the mad cow disease (1986, the United Kingdom), dioxin-containing chicken (1999, Belgium), cooked meat contaminated with listeriosis-causing bacteria, *Listeria monocytogenes* (2001, France), and food contaminated by the Fukushima nuclear plant radiation (2011, Japan). These have triggered public concern and panic about the quality and safety of agricultural products. In response, the European Union (EU), the United States, Canada, Japan, South Korea, and other countries and regions have developed agricultural

products' food traceability systems and have made significant progress in strengthening their legal and regulatory systems, as well as creating technical support systems.

In the past 20 years, China has also experienced a number of major quality and safety accidents involving agricultural food; these include the use of the food additive called Sudan III (2005), red-salted duck egg in Lake Baiyangdian (2006), poisonous leek in Qingdao (2010), poisonous kidney beans in Hainan (2010), fake donkey meat sold by Walmart (2014), and dioxin-containing crabs supplied to Hong Kong. The concern of central and local governments at all levels has gradually shifted from ensuring only the quantity safety of agricultural products to ensuring both their quantity and quality safety. The promotion of a quality and

**Received date:** March 27, 2018; **Revised date:** April 3, 2018

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**Funding program:** CAE Advisory Project "Research on Development Strategy of 'Internet Plus' Action Plan"(2016-ZD-03)

**Chinese version:** Strategic Study of CAE 2018, 20 (2): 057-062

**Cited item:** Hu Yunfeng et al. Current Status and Future Development Proposal for Chinese Agricultural Product Quality and Safety Traceability. *Strategic Study of CAE*, <https://doi.org/10.15302/J-SSCAE-2018.02.009>

safety traceability system for agricultural products has gradually become an important responsibility of the central and local governments.

It has been widely recognized that the construction of a traceability system for agricultural products is of great significance for ensuring food safety all the way from the farm to the table in China and overseas. In China, the Central People's government also has a vision related to the establishment and improvement of the traceability system for agricultural products; in this connection, retrospective pilot and demonstration work on individual agricultural products in the regions has been carried out [1,2]. Since 2015, with the increasing consensus around the "Internet plus" initiative, the state has more clear and specific target, content, and action measures for the use of Internet resources. These help coordinate different levels of resources, as well as different departmental resources, and build a single agricultural products' quality and safety traceability system for the whole nation.

## 2 Traceability of agricultural products abroad

Since the outbreak of the mad cow disease in the United Kingdom, the United Kingdom and the European Union have taken the lead in explicitly proposing a traceability system for agricultural products. It is generally believed that the European Union has been the initiator and promoter of the development of an agricultural products' traceability system, and the United States, Canada, Japan, and other countries are also actively developing such traceability systems.

### 2.1 European Union

Regarding the development of the tracing platform, the European Union established the Rapid Alert System for Food and Feed (RASFF). Based on the RASFF system, food and feed regulators in the European Union member states and some non-member countries can publish and receive food and feed risk information, as well as bring forward, and respond to recall information of food and feed. Since 2014, the European Union has established a dedicated RASFF portal to provide food recall and public health warnings to consumers. The RASFF database has been created to provide open information services to consumers, operators, and government agencies in other parts of the world.

In terms of retrospective technology research and development, the European Union began to implement a large research project called Promoting European Traceability Excellence and Research (PETER) in 2002. The PETER program also includes 9 key sub-programs (TRACE, Co-Extra, SEAFOOD+, GTIS CAP, GeoTraceAgri, DNA-TRACK, OLIV-TRACK, ALCUEFOOD, and FoodTrace), which carried out research in many fields, such as traceability processes, gene and non-gene product management, aquatic products, geographic information technology, and

DNA technology application. In 2008, as one of the core outputs of the TRACE program, the *Good Traceability Practice* (GTP) was introduced to the European Union. GTP decomposes the traceability process into two parts: intra-enterprise and inter-enterprise traceability. It also regulated the information import, traceability unit, and identification code in the traceability process and defined the XML format for the traceability information acquisition and exchange in the supply chain (the Trace Core XML format). In addition to the Core XML standard, GTP is also compatible with the internationally accepted Globe standard 1 (GS1) traceability language standard.

In addition to agricultural products' quality and safety traceability systems development led by governments, some major European retailers and industry alliances have also taken action to supplement product traceability requirements under their original procurement standards. Detailed documents on agricultural products and food are included in the Global Standards for Food Safety promulgated by the British Retail Consortium (BRC) and the International Food Standards produced by the German retail federation (HDE) and French retail federation (FCD) [3,4].

In fact, the European Union has strong legal support for the work on agricultural food traceability. At present, the European Union has established a complete set of legal systems and technical support systems for food and food safety traceability, with REGULATION (EC) No 178/2002 being at its core. These laws and regulations are the basic reference for the formulation of laws and implementation rules by the European Union member states and major enterprise alliances, as well as the basic access specifications for agricultural products and food entering the European Union market from other countries in the world.

### 2.2 United States

In terms of legal construction, the United States has established a legal framework for the traceability of agricultural products based on the *Public Health Security and Biological Terrorism Prevention Act of 2002* and the *Food Safety Modernization Act* (FSMA). In 2004, the United States Department of Agriculture (USDA) published a document of *Traceability in the U.S. Food Supply: Economic Theory and Industry Studies*, which stipulated information collection and tracking related to the production and circulation of farm products such as livestock products, bulk grains, and fruits and vegetables. In addition, the USDA has also published the *Meat, Poultry and Egg Product Inspection Directory* (MPI Directory), *Perishable Agricultural Commodities Act* (PACA), and the *Organic Foods Production Act of 1990*, which provide more detailed requirements for ensuring specific agricultural products' traceability.

In terms of standards and specifications, the United States Food and Drug Administration (FDA) published a series of normative guidelines, such as the *Guidance Documents & Regulatory Information, Guidance for Industry: Product Recalls*,

*Including Removals and Corrections*, and the *DA's Guidance for Industry: Questions and Answers Regarding Food Facility Registration*; these are a series of norms on the detailed interpretation of the relevant retroactive provisions in the law.

In terms of application system development and traceable industrial ecological environment development, many agricultural product enterprises and industry associations in the United States have spontaneously established a large number of internal trace systems of enterprises or industries; further, the Institute of Food Technologists (IFT) of the FDA has established the Global Food Traceability Center. This center coordinates the strengths of companies, governments, academia, foundations, consumers, etcetera, and focuses on integrating global food traceability resources to achieve full chain traceability of agricultural products.

### 2.3 Inspirations

Summarizing and analyzing the experiences, especially the successful ones, in the development of agricultural products' traceability systems in developed countries and regions, such as the Europe and the United States, we find the following.

First, the establishment and development of agricultural products' quality and safety traceability systems promotes agricultural modernization and ensures public safety. The traceability system for agricultural products plays an important role in safeguarding the quality and safety of agricultural products and ensuring the fulfillment of the government's responsibility for food safety supervision of agricultural products. In the process of development, using information technology to promote the degree of agricultural organization and modernization, promoting the transformation and upgrading of traditional agriculture to information agriculture and smart agriculture, and promoting structural adjustments and changes in development ideas on the supply side, circulation side, and consumption side of agriculture have a positive effect on innovation [5,6].

The government plays a key role in the development of agricultural products' traceability systems. Governments have promulgated laws and regulations, laying a foundation for the mandatory implementation of agricultural products' information collection, information traceability, and a high degree of information reliability. Governments have formulated unified traceability standards and coding rules, creating a technical benchmark for the development of a wider range of agricultural products' traceability systems, coordination, and international standards. Government departments support the research and development of relevant standards, norms and application systems, and information platforms; they also provide early protection for key technological breakthroughs in agricultural products' traceability system construction, public service and commercialization, and industrial operation.

In the development of agricultural products' traceability system, the unified traceability coding system is the foundation, and

innovative technologies, such as the Internet of things (IoT) and big data, are of great significance for the entire process and deep traceability of agricultural products. At present, the global traceability standard based on GS1 is recognized internationally. In the areas of identification technology, the IoT, big data technology, mobile services, and the development of related technologies at home and abroad, are changing with each passing day and achievements through innovation are constantly emerging. Modern information technology has become the basic bulwark for the construction and industrialization of agricultural products' quality and safety traceability systems. Technological innovation will become the key driver for the development of the agricultural products' quality safety traceability industry.

## 3 Traceability of agricultural products in China

Since 2007, the party and the government have made important plans to cover the entire value chain from the field to the table, establishing a national unified agricultural product and food safety information traceability platform and carrying out demonstration pilot work in relevant departments and regions. Since 2015, the State Council has issued the following: *Guidelines on Promoting Internet Plus Initiative*; *The Three-Year Action Plan for Internet Plus Modern Agriculture*; and *National Agricultural Modernization Plan (2016-2020)*, to make specific arrangements for the main objectives, development content, development path, and system guarantee for the development of agricultural products' quality and safety traceability systems.

### 3.1 Laws and regulations

Since 2000, the following central government bodies of the People's Republic of China have made many efforts related to the development of agricultural products' traceability systems: Ministry of Agriculture and Rural Affairs (MOA); Ministry of Commerce (MOFCOM); China Food and Drug Administration (CFDA); General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ); and Entry-Exit Inspection and Quarantine Bureau. In addition, local governments have also participated in this effort and some progress has been made in the construction and improvement of regulations.

In terms of the development of the legal system, the *Law of the People's Republic of China on Quality and Safety of Agricultural Products*, promulgated in 2006, stipulates the basic requirements for agricultural products in terms of "safety standards, origin, production, packaging labeling, supervision and inspection, and legal responsibility." *The Food Safety Law of the People's Republic of China*, issued in 2015, went further and laid down requirements for labels and recalls.

Regarding administrative regulations at the national level, the MOA has successively issued rules and regulations, such as the *Administrative Measures for the Management of Livestock*

and Poultry, the *Administrative Measures for the Packaging and Marking of Agricultural Products*, and the *Administrative Measures for the Safety of Places of Origin of Agricultural Products*. The MOFCOM has issued *Guidelines on Accelerating the Construction of the Traceability System for the Distribution of Meat and Vegetables during the Twelfth Five-Year Plan* and other documents. These regulatory departments have laid down some requirements for the development of traceability system in the process of production and circulation of agricultural products. In addition, based on their regional characteristics, all parts of the country put forward local rules and regulations for the production and circulation of agricultural products.

It should be pointed out that for the traceability of agricultural products, the current legal requirements at the national level still focus on general quality and safety requirements, and there is no clear legal requirement for traceability. In the texts covering departmental rules and regulations and local regulations, a theoretical description of the demand and development vision are presented; however, there is still much room for improvement in the specific implementation and operability of the documents.

### 3.2 Standard coding

By searching in the China Standard Service Net (<http://www.cssn.net.cn/>), the current domestic standards for a total of 43 items related to “trace” are obtained (retrieved on November 2016). Further analysis shows that most of the standards are recommended standards. There are only four mandatory standards—one in the environmental category, two in the military category, and one local standard. There are six national standards, all of which are for agricultural products (including feed and food). Further, nine industry standards are published by the MOA. All of them are general specifications for the traceability of agricultural products' quality and safety. MOFCOM has published 20 standards, focusing on agricultural products. The traceability process, equipment, and specific systems of meat, vegetables, food, and medicinal materials are regulated; in addition, there are also three aquatic standards, which specifically regulate farmed aquatic products.

In terms of traceability coding of agricultural products, the Article Numbering Center of China issued the *Guidelines for Tracking and Traceability of Beef Products* and the *Guidelines for Tracking and Traceability of Fruits and Vegetables* in 2004. These specifications use globally accepted identification technologies, such as item codes, commodity barcodes, and radio frequency identification (RFID) to achieve food safety tracking and traceability. After 2007, the MOA successively issued the *Regulations on the Coding Code of Production Area of Agricultural Products*, *Guidelines for the Traceability Code of Agricultural Products*, *Operating Rules for Quality and Safety Traceability of Agricultural Products*, and the traceable operation procedures for specific large-scale agricultural products, such as fruits, tea,

meat, grains, and vegetables. In addition, the *Guidelines for the Design of Agricultural Products Traceability Information System*, *Measures for Administration over Quality and Safety Certificates for Edible Agricultural Products*, and the *Standards for the Management of Agricultural Products Quality and Safety* are also being developed and compiled.

After 2002, the AQSIQ issued the *EAN-UCC System 128 Bar Code* (GB/T 15425-2002) and the *Commodity Barcode 128 Bar Code* (GB/T 15425-2014). In 2004, the *Outline Procedures for Outbound Aquatic Products (Trial)*, *Inspection and Quarantine and Supervision Requirements for Outbound Aquaculture Products (Trial)*, and other standard specifications were issued to link the European Union's traceability requirements for the trade of aquatic products. In addition, the 27 GAP texts published after 2005 provide a national-level voluntary product certification benchmark for China's primary agricultural products' quality and safety control.

In summary, although the standard norms for the traceability of agricultural products' quality and safety have been adopted late, they have essentially been linked to international standards. The main problem is that the development and application of the standards for agricultural products are subject to the stage and level of industrial development and the overall deployment requirements in the country for traceability. The mandatory standards, as well as the degree to which they are applied, lag those of developed countries.

### 3.3 Key technology

A total of 2406 articles were retrieved from the China National Knowledge Internet (CNKI) by searching the keyword “agricultural products & traceability” (retrieved on November 15, 2016). An annual analysis of literature results shows that since 2000, researchers have increasingly developed the theory, methods, and systems of agricultural products' traceability. Since the term “traceability of agricultural products” was coined from the perspective of comparison between Chinese and Western culture in 2002, the number of research papers published by researchers has steadily increased. After 2014, domestic researchers published papers that were stable at more than 350 articles; the papers published over the past three years accounted for 41.9% of the total number of papers published in the last 15 years (2000 to 2017).

The in-depth analysis of the published literature shows that studies by domestic researchers on the development of agricultural products' quality and safety traceability systems mainly focus on product identification technology, multi-source information collection, comprehensive decision-making, and big data applications.

In terms of product identification technology research, considering the characteristics of agricultural products, researchers have conducted a large number of comparative studies on

one-dimensional barcodes, two-dimensional QR codes, RFID, and other marking technologies [7,8]. In addition, they have also analyzed the potential of biometric-based product identification technologies, such as DNA, autoimmune antibody tags, nose lines, retina- and face-recognition technologies, in agricultural products' traceability.

In the field of multi-source information collection, it is necessary to carry out full-process and all-round information collection for the three key areas of production, logistics, and sales of agricultural products. Therefore, research and development of information acquisition devices with low cost, low energy consumption, and flexible deployment have become the key direction of domestic research. Modern IoT technology, based on the wireless sensor network (WSN), provides strong support for collecting information and updating agricultural products. The rapid development of various portable terminals, such as mobile phones, also makes it convenient to collect and update information [9].

In comprehensive decision making, with the rapid development of information technology and communication technology, forecasting and early-warning systems based on real-time monitoring and decision making based on artificial intelligence (AI) are gradually becoming possible [10,11]. At present, researchers have used satellite remote-sensing technology, image-recognition technology, and AI technology to control the growth environment and processes of large-acreage crops, orchards, field vegetables and greenhouse crops, forecast crop harvest, and quickly classify crop quality by mechanization.

In summary, the current research on agricultural products' traceability is working in the direction of enriching traceability information and improving traceability. Developments based on use of the cloud platform, edge computing, and AI to achieve multi-platform, multi-terminal agricultural products' quality and safety traceability information collection, update, auxiliary decision making, and information querying are the technological hotspot in the field of agricultural products' quality safety traceability research.

### 3.4 System platform

Since 2003, the AQSIQ, MODCOM, MOA, and other relevant ministries have carried out a series of pilot and demonstration projects for agricultural products' traceability in their respective sectors. For example, the AQSIQ implemented the "China Barcode Promotion Project" and achieved more than 100 innovations related to product quality and safety traceability application across the whole country. The CFDA has carried out pilot projects for meat food traceability systems and system construction projects; the MOFCOM has carried out the development of a trace system for the circulation of meat and vegetables in 58 cities; the MOA has established a "Retrospective Display Platform for Agricultural Reclamation Agricultural Products

Quality" in the agricultural land reclamation system, an "Animal Labeling and Disease Traceability System" for animal products, and a "Water Product Quality and Safety Traceability Network" for aquatic products. In June 2017, the MOA announced the launch of the "National Agricultural Products Quality and Safety Traceability Management Information Platform," which marked a major step in the traceability of China's agricultural products.

A search for "Agricultural Products + Traceability" was carried out on Google and Baidu, and more than 40 agricultural products' traceability platforms with high rankings and visibility were explored in detail. Further research of these platforms revealed that 25 network information query platforms are still running. In the above 25 platforms, there are a total of 9 websites that have the domain name gov; most of these are sponsored by the MOFCOM, Bureau of Reclamation under the MOA, and various local government departments. These websites usually have a comprehensive product traceability platform that includes food and agricultural products, and there is a variation in the extent of coverage for those at the country-level and others at the county-level. There are 8 websites with the domain name org; most of them are sponsored by various industry associations and local standardization committees. These sites usually focus on specialized categories (e.g., bee and tea products), specialized links (e.g., circulation), or a comprehensive platform that is limited to specific regions (e.g., provinces and cities). There are 8 websites with the domain name com; most of these are sponsored by relevant commercial companies. These websites generally have local agricultural and commercial authorities as the business supervision unit and are usually a comprehensive information query platform with a broad range of product categories.

In summary, various departments and regions have developed some agricultural products' traceability systems for their own departments and regions and have also formed certain service capabilities. However, in general, the service areas and service targets of these traceability systems and traceability platforms are quite narrow, the sustainable service capabilities are weak, and the commercial operation capabilities are obviously backward; the construction of agricultural products, irrespective of the level of industrialization is not on the agenda yet.

## 4 Suggestions for development

In the future, by following guidance documents, such as the *Guidelines on Promoting Internet Plus Initiative*, *National Agricultural Modernization Plan (2016-2020)* by the State Council, and the *Opinions on Accelerating the Construction of Agricultural Products Quality and Safety Traceability System* by the MOA, the development of China's agricultural products' quality traceability system should focus on strengthening the following four aspects of construction and forming corresponding technological and breakthrough achievements:

- (1) Building a national-level unified traceability platform:

Integrating the resources and strengths of existing departments, opening up the administrative boundaries between various departments and regions, and building a traceability platform for agricultural products' quality and safety supervision that covers the whole country; further, it would be compatible with various departments, both upstream and downstream, providing free and value-added services for government supervision, corporate use, and personal inquiries.

(2) Achieving breakthroughs in key technologies for complete and thorough traceability of agricultural products. This can be done by breaking through the application bottleneck of next-generation technologies, such as mobile Internet, big data, cloud computing, and the IoT in the traceability of agricultural products and upgrading the traceability services at the farm, processor and retailer level. Further, this can be achieved by high traceability of key links in the value chain, such as planting, breeding, production, processing, logistics, and wholesale, and by focusing on the role of technologies, such as blockchain, in retrospective data exchange.

(3) Improving the traceability system and system standards. This can be achieved as follows: carrying out and completing the specific legislative work of China's agricultural products' traceability and improving and innovating the traceability system and mechanism of agricultural products; citing the existing mature standards and norms of the international community and absorbing the advanced experience and institutional norms of developed countries to improve the traceability standard of agricultural products suitable for the development level and characteristics of China's agricultural industry; and establishing a mechanism for the connection between the origin of production and market access based on the traceability platform to improve the response mechanism for agricultural products' quality and safety issues.

(4) Creating a sustainable commercial operation for the agricultural products' traceability ecosystem. Innovating the national agricultural products' quality and safety traceability system construction, operation, and service mechanism; forming an open and shared agricultural products' traceability information big data platform to achieve refined management and service of agricultural production, management and consumption; and forming a traceable ecosystem of agricultural products for sustainable commercial operations.

In general, even with the advent of the Internet Plus era and the continuous development of advanced technologies, such as big data, cloud computing, edge computing, and blockchain, effective tracking of the quality and safety of agricultural products does not exist in the technology itself. The main factors that hinder the development of China's agricultural products' quality and safety traceability systems are the structure of the legal system, as well as the lack of integration of resources and application innovations. Therefore, we recommend the following:

(1) Study and formulate the *Traceability Law for Agricultural*

*Products Quality and Safety* as soon as possible. At present, the *Law of the People's Republic of China on Quality and Safety of Agricultural Products* and the *Food Safety Law of the People's Republic of China* essentially do not address the traceability of agricultural products. It is suggested that the state proceed from an overall agricultural development strategy and initiate planning and legislation for the construction of an agricultural product traceability system from the perspective of strategic development of the national new-normal economy. Special agricultural products' quality and safety traceability laws that introduce more stringent legal requirements for the traceability of agricultural products' quality and safety should be promulgated as soon as possible. This will ensure that the system moves from being reliant on regulations to ensuring compliance to one that can invoke specific laws and penalties to achieve its objectives.

(2) Clarify the responsibility of the main body for supervision of agricultural products, integrate the resources of various departments at all levels, and implement the retrospective and unified supervision of agricultural products. At present, the MOA, the AQSIQ, the MOFCOM, the MIIT, the CDFA and other local governments are the main regulatory bodies of specific agricultural products or an administrative region. The status of multi-sector, multi-regional, multi-system, multi-channel operation is susceptible to the "when multiple people are responsible for management, no one is responsible" issue, the "information island, difficult to produce benefits" issue, and other such issues. It is recommended that the state clarify the main body for the supervision of agricultural products, integrate resources, and establish a national unified agricultural products' quality and safety traceability supervision system. The focus should be on transforming traditional departmental supervision and regional supervision modes, unifying standardization and standardization, unifying platforms and systems, and forming a national agricultural products' traceability platform with unified and consistent standards, as well as unified export.

(3) Strengthen the Internet plus application innovation, and achieve "corner overtaking." The modern agricultural products' traceability system should be supported by advanced information technology. At present, traditional GS1 traceability languages and RFID technologies are becoming more and more popular, and a new generation of DNA technology, artificial intelligence technology, cloud computing technology, and blockchain technology is developing rapidly. It is recommended that the state increase its investment in science and technology; strengthen research on cutting-edge technologies in modern agriculture, modern logistics and modern service industries; attach greater importance to the opportunities and challenges brought about by the Internet Plus era; and make use of the large capacity of the market, the strong consumption ability, the rapid development of the IT foundation, and the strong viability of the IT enterprises to implement model innovation of agricultural products' traceability technology and system in the Internet Plus era. This will

help China achieve “corner overtaking” in construction of its agricultural product tracing system.

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