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Food Safety Traceability

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33.1 Introduction

With globalized economics, it is becoming more frequent to trade food across country and regional borders, which leads to expanding and spreading of all kinds of food safety incidents and hazards. Mad cow disease, foot and mouth disease, avian flu and other zoonotic diseases pose a grave threat to food safety and human health, causing serious economic losses for food industries and causing social panic at the same time. In order to reduce the losses caused by such serious zoonotic diseases, as well as to ensure food safety, many countries have started to implement food safety traceability systems. The European Union has the most advanced regulations on food traceability. EU regulation No. 178/2002 requires all food products within the European Union be trackable and traceable, starting from January 1, 2005, otherwise they cannot be sold [1]. The EU also has other regulations targeting specific food products, such as regulation No. 1224/2009 for fisheries and aquaculture products, No. 931/2011 for food business operators with respect to food of animal origin, regulation No. 1337/2013 on the country of origin or place of provenance for fresh, chilled and frozen meat from swine, sheep, goats and poultry, and Nos. 1829/2003 and 1830/2003 relating to the authorization, labelling, and traceability of genetically modified food and feed. The US Food and Drug Administration (FDA) requires all US and foreign facilities engaged in food production, processing, packaging, or managing people or animal consumption must register with the FDA prior to 12 December 2003 to ensure food safety tracking and tracing. The Bioterrorism Act of 2002 (BT Act), and the record keeping requirements contained within, represented a major step forward in the implementation of a product tracing system for FDA-regulated food products. This Act requires a paper trail documenting food distribution, to allow determination of the source of contamination in the event of a food-borne illness outbreak. The FDA Food Safety Modernization Act (FSMA) was signed into law by President Obama on 4 January 2011. It aims to ensure the US food supply is safe by shifting the focus of federal regulators from responding to contamination to prevention. Section 204 of the FSMA requires the US FDA to develop additional record-keeping requirements for high-risk foods, to improve their traceability. These mandates

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are yet to be published and are expected to be available in draft format in the coming years. During September 2011, the FDA tasked the Institute of Food Technologists (IFT) to conduct two pilot studies on traceability to explore and demonstrate methods for rapid and effective tracking and tracing of food, including types of data that are useful for tracing, ways to connect the various points in the supply chain, and how quickly data can be made available to the FDA. The final report was released in 2013, with findings from pilot projects, and the IFT's recommendations to the FDA for improving the tracking and tracing of food. In September 2013, the IFT launched the Global Food Traceability Center (GFTC), a science-based, not-for-profit public-private partnership. It brings together key stakeholders in the food system to collaborate on traceability solutions and serves as an authoritative source for food traceability.

There are no specific traceability regulations for food commodities in Canada other than for livestock. However, traceability of processed food products is verified through proper packaging and labelling in accordance with the Consumer Packaging and Labelling Act and regulations, and specific regulations for individual food commodities, as well as the Food Safety Enhancement Programs (FSEP) for meat products. The Japanese Ministry of Agriculture, Fishery and Forestry (MAFF) has mandates under its beef traceability program for domestic beef, requiring that an assigned number is carried through from the birth of the cow, to the processed carcass at the abattoir, and the label on the final packaged product, or its invoice. The rice law enacted in 2009 requires record keeping of transactions of rice and grains, and informing consumers and business partners of origin information, to allow prompt identification of the distribution route when a problem occurs.

A food traceability system has been recognized as an effective measure for food safety supervision and management, and it is an important tool to monitor the entire "farm to table" process, to ensure the fast recall of "problematic food", to reduce economic losses, and to improve consumer confidence.

The Chinese government gives high priority to the development of a food safety traceability system. Considerable work has been carried out, from the establishment of regulations, laws and policies, through development of traceability technology platforms, and research and development, to industrial demonstrations.

33.2 Legal Regulations

The State Administration for Quality Supervision, Inspection and Quarantine started the implementation of the "Exit Aquatic Products Traceability Rules (Trial)" in June 2004, which requires the export of aquatic products and its raw materials be labelled in accordance with the provisions of the regulations. The export of aquatic products can be traced back from the finished products to the raw materials by the labels on the outer packaging. China implemented the "Agricultural Product Quality Safety Act" in November 2006. Article 24 of the Act states: that agricultural producers and rural specialized cooperative economic organizations should establish agricultural production records, and record accurately the following: (1) the name, source, usage, dosage and start/end date of agricultural inputs; (2) animal diseases and the occurrence and prevention of plant pests; (3) date of harvest, slaughter or harvest. Agricultural production records shall be kept for two years, and the fabrication of agricultural

production records is prohibited. The state encourages other agricultural producers to establish agricultural production records. The Ministry of Agriculture (MOA) issued “NY / T1430-2007 Agricultural Product Production Site Encoding Rules” [2] and “NY / T1431-2007 Agricultural Product Traceability Coding Guidelines” [3] in 2007. The coding terminology and definitions for the production sites of agricultural products, segregation principles for production units, coding rules for production sites, the unit data requirements for production sites, and coding principles of agricultural products were all regulated. In 2010, the MOA released NY/T1940-2010 Tropical Fruits Categorizing and Coding System [4], which sets out the principles and methods of classification of tropical fruits, the coding method, and classification codes. Articles 36 to 39 of the 2009 Food Safety Law clearly defined that food production enterprises should establish a record system for food ingredients, food additives, and food-related products. Warehouse inspections need to faithfully record the name, size, quantity, supplier name and contact information, and purchase date of food ingredients, food additives, and food-related products. They should establish a food factory inspection records system, check food factory inspection certificates, and the food safety situation, and accurately record the food name, specification, number, production date, production batch number, inspection certificate number, name and contact information of purchasers, sales date, and so on. Food enterprises should establish a food purchase inspection record system to faithfully record the food name, specification, quantity, batch number, shelf life, supplier name and contact information, purchase date, and so on. These inspection records should be truthful and the retention period should not be less than two years. In 2015 the newly revised “Food Safety Law” Article 42 clearly states that the national government should establish a full traceability system for food safety. The food producers should be in accordance with the provisions of this law, and develop a food safety traceability system to ensure food traceability. The state encourages food producers and traders to use systems to collect information, retain production and management information, and establish food safety traceability systems. Clearly, Chinese laws and regulations on the developments of food safety traceability systems are maturing.

State regulations have specific requirements for food safety traceability system development. The 2012 Central One document proposed to strengthen overall coordination of food quality and safety supervision, by strengthening the inspection and traceability systems. The 2013 Central One document proposed the full implementation of regulatory responsibility from the farm to the table, to improve the quality and safety traceability system for agricultural products. It also required rigorous production and operation management for agricultural inputs, and required a record system be established for agricultural inputs. The 2014 Central One document proposed to establish the most stringent food safety regulatory system covering the whole process, to support food traceability systems, and to establish rigorous production management systems. The 2015 Central One document also demanded the improvement of agricultural product quality and food safety standards, increasing the regulatory capacity of agricultural product quality and food safety at the county level, and establishing a full traceability information platform with internet sharing capability for agricultural product quality and food safety. The 2014 State Central Rural Work Conference also proposed to control strict use and misuse of agricultural inputs, and to establish a sound agricultural and food safety traceability system, and establish a unified national agriculture and food traceability information platform as soon as possible.

33.3 Food Safety Traceability System

In order to ensure food safety for the 2008 Olympics, Beijing city government established the Olympic food safety monitoring and traceability system in January 2008, with a full monitoring system “from farm to table” for all the food supplies, especially poultry and meat. Starting with a pilot study first with specific focuses, the Ministry of Commerce and Ministry of Finance supported pilot studies in 35 cities in three batches starting from 2010, created a meat traceability system, explored and utilized the information technology management market, strengthened food safety system management, and modernized the circulation of commodities. By the end of 2013, the development of the meat product traceability system had made remarkable achievements. The first 10 cities completed the development of traceability system covering a total of 3007 companies, including 134 slaughterhouses, 77 wholesale markets 1766,631 large supermarket chains, and 399 consumer group units. It covered mechanized slaughterhouses, wholesale markets, all large- and medium-sized supermarket chains in the inner cities, improved the safeguarding capability for food safety and quality, and enhanced the scientific level of modernization and industrial management in the supply chain.

Beginning in 2004, the MOA started a traceability system pilot project. The State formally established a reclamation agricultural product quality traceability system in 2008. By the end of 2013, the number of companies participating in this system reached 283, and reached 350 by the end of 2014. The system covered 28 provinces and autonomous regions, excluding Tibet, Qinghai, and Shanxi Provinces. The system covered major agricultural products such as grains, vegetables, fruits, tea, poultry and meat products, eggs, fish, milk, seeds, and other agricultural inputs, wine, and other processed products. The system introduced numbers of traceable products with good brand reputations and safety capabilities to domestic and foreign markets.

Agricultural inputs traceability regulation is an important measure to protect agricultural product quality and safety from source. The Institute of Food Science and Technology in the Chinese Academy of Agricultural Sciences developed the “Agricultural Inputs Traceability Management System,” funded by the agricultural product quality and safety supervision project, “Agricultural inputs Information Platform Development and Demonstration,” initiated by the MOA, which has been demonstrated and implemented in Hubei, Hunan, Fujian, Shandong, Jiangsu, Jiangxi, Anhui, Guizhou, Inner Mongolia, and Liaoning provinces. The system combines government regulation, business management, and consumer purchase query capabilities, and addresses interfacing problems between different regional information management systems, to achieve a national regulation network.

The food traceability system is a complicated systematic project involving multiple agencies and disciplines, with appropriate technology support. Barcodes, RFIDs, information technology and network-based electronic data tracking technology are the foundations for the whole food chain traceability system. The food system has a variety of food products, long industrial chains, and diverse information to be recorded; how to guarantee the authenticity of the traceability information is the key to the development of a food traceability system. Therefore, the system also requires good faith and science-based regulatory support. Currently, scientific research is focusing mainly on the identification of plant and animal species and varieties, as well as technologies to identify the origins of products.

33.4 Food Traceability and Verification Technology

33.4.1 Plant and Animal Species Identification Technology

With the “horse meat scandal,” “adulterated meat,” and other food safety issues arising, animal and plant species identification technology is a growing concern in the academic world. At present, the approaches that can quickly and accurately identify animal species are mainly based on proteomics, chromatography, spectroscopy, and DNA fingerprinting techniques.

33.4.1.1 Proteomics Analysis

Proteins (enzymes, myoglobin, etc.) have been widely used for species identification. The electrophoretic patterns of water-soluble proteins are often associated with animal breeds. Starch gel electrophoresis, polyacrylamide gel electrophoresis, agarose gel electrophoresis and isoelectric focusing electrophoresis are used to separate water-soluble proteins. Gel electrophoresis for protein detection has detection limits between 0.1% and 1%, depending on the clarity of the protein bands. Microimmunological techniques, such as Western blots and enzyme-linked immunosorbent assays are mainly used for microanalysis of solid-phase target proteins, and can also be used for the quantitative analysis of animal species. The detection limits depend on the meat varieties in the animal products tested: for pork $\leq 1\%$, poultry and beef $\leq 2\%$, and lamb $\leq 5\%$ [5]. With specific protein band patterns, animal species, varieties, and strains can be distinguished.

33.4.1.2 Chromatography/Spectrometry Methods

Chromatography and spectroscopy metabolomic methods can identify the authenticity of animal and plant products, and classify the different varieties. Rochfort *et al.* (2013) used nuclear magnetic resonance (NMR) and gas chromatography mass spectrometry to analyze water-soluble and fat-soluble metabolic component in Australian blue mussels (*M. galloprovincialis* varieties) and New Zealand green mussels (*P. canaliculus* varieties). They found significant differences in the metabolic components from different varieties [6]. Son *et al.* (2008) used ^1H NMR to identify the origins of different varieties of grapes [7]. Wu *et al.* (2015) differentiated and identified nectar honey from difference sources in China (canola flower honey, acacia honey, vitex honey, and date honey), with a correct classification rate of 100% [8]. Lu *et al.* (2014) used UPLC-MS and chemometric methods and successfully identified Chinese Goji samples from different areas and different species [9].

33.4.1.3 DNA Fingerprinting Methods

In recent years, DNA analysis techniques have been widely used in food research and control. DNA testing for identification of food varieties was originally used for hybridization analysis using specific DNA probes [10, 11]. Currently, the polymerase chain reaction (PCR) is used as a key technology for species identification in food and feed products. It is often used with restriction fragment length polymorphism (PCR-RFLP) on plants and animals to identify varieties of food [12]. Random amplified polymorphic DNA-polymerase chain reaction (RAPD-PCR) based on single strand conformation polymorphism (SSCP) has also been used to distinguish between different species of animals and plants in the studies [13].

Many specific PCR systems may be used to analyze plant and animal species, and the analytical accuracy of these techniques is very high. They can be used for species identification of complex samples, even for processed foods (e.g. sterilized), and the system is very effective. Typically, the detection limit of DNA technology is $\leq 0.1\%$, depending on the detection limit of the PCR method used [5]. Currently, the method has been used for grapes [14], seafood [15], cereals [16], and other food varieties.

33.4.2 Food Origin Identification Technology

With environmental pollution, food safety incidents, as well as the protection of product origin and other issues, the origins of food products have become an issue of great concern for the government authorities and consumers. On one hand, food production sites are closely associated with disease outbreak and pollution events. When food safety incidents occur, the region of occurrence is identified for traceability of food origin as the basis for tracing the harmful source. On the other hand, the nutritional quality of food and its origin are closely related; tracing the food origin will facilitate the implementation of regulations and the protection of products from particular areas.

Currently, the EU has three labels for special regional product certification, namely Protected Designation of Origin (PDO), Protected Geographical Indication (PGI), and Traditional Specialty Guaranteed (TSG) [17]. The previous China State Administration of Quality and Technical Supervision issued a Geographical Origin Protection Regulation in August 1999, indicated the initial establishment of a geographical indication protection system with Chinese characteristics. In June 2005, the State Administration of Quality Supervision, Inspection and Quarantine promulgated the Provisions for the Protection of Geographical Indication Products, based on the merging of the existing Geographical Origin Protection Regulations and the Place of Origin Symbol Regulations, showing further development of the geographical indication protection system in China. In February of 2008, the MOA implemented a list of Geographical Indications of Agricultural Management Practices [18]. China has now approved more than 2000 kinds of geographical indication products.

In the real food production and supply chain process, driven by economic interests, some unscrupulous traders will use the fake products to replace genuine ones and replace good quality products with bad quality products, as well as using products from other regions to replace geographical origin products. They deceive the consumers, create food safety problems, and cause confusion in the geographical origin product market, thus harming consumer interests and impacting the credit system for industry and enterprises. Food origin and validation technologies have been developed in recent years, providing technical support for the food chain traceability system and regulation of these geographical origin products.

33.4.2.1 Traceability Technology Principles and Applications for Food Origin

Food origin and validation technology explores the characteristic indicators of food from different regions. Stable isotope fingerprints, mineral element fingerprints, IR fingerprints, and organic ingredient fingerprints are often used in food traceability and validation research. The traceability principles and characteristics of different technologies vary.

Stable isotope fingerprinting. In nature, organisms constantly exchange substances with the environment. The compositions of $^{13}\text{C} / ^{12}\text{C}$, $^{15}\text{N} / ^{14}\text{N}$, $^2\text{H} / ^1\text{H}$, $^{34}\text{S} / ^{32}\text{S}$ and other stable isotope in the body are impacted by climate, environment, types of biological metabolism and other factors. Natural fractionation will occur and cause differences in natural isotopic abundance from different sources. This difference carries information about environmental factors, reflects the environmental conditions in which an organism lives, and can be used as a “natural fingerprint” to distinguish between substances from different regions [19]. Therefore, isotopic fingerprints are the natural labels of all creatures, closely related to the growth environment of an organism, and does not change with chemical additives. It provides food traceability in a scientific, independent, and immutable way, with identity authentication information flowing throughout the food chain. Isotopic analysis has the advantages of a simple sample preparation procedure for pre-testing, small sample size, high precision, and fast analysis speed.

For tracing food origin, isotopes of H, O, C, N, S, B, and Sr are commonly used. Most research has focused on analyzing the differences in isotopic compositions of foods from different geographical regions, analyzing the isotopic compositions of food components, the correct classification rate of isotopic indicators of food origin, establishing a traceability database, and mapping the traceability of food origin. Chinese experts and scholars have confirmed the effectiveness of the use of stable isotopes for food products such as beef [20], lamb [21], fish [22], and blackcurrant [23].

Mineral element fingerprinting. Affected by geology, water, and soil environmental factors, differences exist in the composition and content of mineral elements of soils from different regions, thus leading to unique and characteristic mineral element fingerprint profiles for organisms growing in different regions. The key to using mineral elements fingerprinting for tracing food origin is to pick out the fingerprint of stable elements associated with the food growing region from a wide variety of elements [24]. Sun *et al.* (2011) collected 99 lamb meat samples from five regions in China and determined 25 elements (Be, Na, Mg, Al, K, Ca, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Mo, Ag, Cd, Sb, Ba, Tl, Pb, Th, and U) using ICP-MS, as well as analyzing the meat samples using a combination of PCA, CA, and LDA. They also selected 12 kinds of elements (Be, Cr, Mn, Fe, Cu, Zn, As, Sb, V, Ba, Ni and Na) using stepwise analysis to develop a discriminating model; this model crosschecked five geographical samples, with an overall correct classification rate of 88.9% [25]. Luo Ting *et al.* (2008) collected 28 green tea samples from four provinces in China (Anhui, Zhejiang, Sichuan, Guizhou) and tested mineral elements such as K, Ca, Cu, Fe, K, Mg, Mn, P, Zn, etc. by inductively coupled emission spectrometry; better distinction between different regions was achieved by analyzing clusters of the first five main components [26]. Zhao (2011) collected 240 wheat samples randomly from four regions in China (Hebei, Henan, Shaanxi, Shandong) for two consecutive years, analyzing for 15 elements (Be, Na, Mg, Al, K, Ca, V, Mn, Fe, Cu, Zn, Mo, Cd, Ba and Th) using ICP-MS. After using multivariate statistical analysis, it was found that the mineral element fingerprint method still had great potential for identifying wheat origin, despite differences in year of harvest, genotype, and field management, which may impact the element content [27].

Infrared spectroscopy. Infrared spectroscopy (IR) refers to a spectrograph which reflects the results of interactions between infrared radiation and the substance analyzed, with the wavelength or wave number as the horizontal axis, and the strength or other properties as functions of the wavelength as the vertical axis. The wavelength

range of infrared rays can be roughly divided into near-infrared (0.8–2.5 μm), mid-infrared (2.5–25 μm) and far-infrared (25–1000 μm .) By using spectrophotometric analysis for spontaneous emissions from substances, or by stimulating emissions using infrared radiation, an infrared emission spectrum is obtained. When the infrared ray absorbed by the substance is analyzed, and infrared absorption spectrum is obtained. Organisms from different regions are affected by the external environment; some differences exist in their chemical composition and structure, thus creating characteristic spectra with different spectral shapes, absorption locations, or intensities [28]. This principle can be used to distinguish and confirm the origin of food. Currently, Chinese scholars have used IR for food origin identification purposes for beef [29], lamb [30], tea [31], wheat [32], West Lake lotus root starch [33], and loquat [34] products.

Organic composition fingerprinting technology. Affected by temperature, humidity, sunshine, rainfall, soil, and other factors, the compositions and contents of organic substances such as fat, protein, carbohydrates, vitamins, and flavors in the same type of food from different regions are significantly different, and have unique fingerprint features. By conducting screening studies of organic compounds in food products that characterize different regions, fingerprinting technology for organic composition can be set up for food source identification.

Yang, Zhuanying and *et al.* (2012) compared and analyzed the sugar composition of litchi fruits from six different regions in the Guangdong Province, such as Guangzhou City, Yangjiang City, Dongguan City, Maoming City, Taishan City, and Longhai. The results showed that the micro-environment and management level of the product region can affect the sugar composition of litchi fruit [35]. Ma, Yiyan *et al.* (2013) tested vitamin C, vitamin E, soluble solids, total acid, and total sugar content of 93 kiwi fruit samples from three main production areas, Zhouzhi and Mei Counties in Shaanxi Province, and Muchuan County in Sichuan Province, and Yongshun County in Hunan Province. The analysis of variance results showed that there were significant differences in the organic compositions with different fingerprints for the kiwi fruits. The kiwi fruits from Zhouzhi and Mei Counties, had the highest vitamin C, but the lowest vitamin E, soluble solids and total sugar contents. The kiwi fruits from Muchuan County, had the highest vitamin E, soluble solids, and total sugar contents, while the total acid content was the lowest. The kiwi fruits from Yongshun County, had the highest total acid content and lowest vitamin C content [36]. Qiu, Qiang *et al.* (2012) planted three high-fat, three high-protein and three common cultivars in six ecological zones of Jilin from 2005 to 2007, respectively, then analyzed the different soybean cultivars to determine the impacts of different ecological effects and conditions on the quality of fat content, protein content, and total fat/protein from each region. The results showed that there were significant differences between the different ecological ranges on the compositions of fat, protein, and total protein and fat [37]. In their research on food animal origin, Chen, Bijun, *et al.* (2012) found significant differences in the compositions and contents of fatty acids in beef from four major beef-producing areas, Jilin, Ningxia, Guizhou, and Hebei. The saturated fatty acid (SFA) content of beef from Jilin and Hebei was significantly higher than from Guizhou and Ningxia, The C16:1 and C18:1 mono-unsaturated fatty acids (MUFAs) in Ningxia beef were significantly higher than other regions. The α -C18:3, C20:5, and polyunsaturated fatty acid (PUFA)-n3 contents in beef from Guizhou and Hebei were significantly higher than those from Jilin and Ningxia. By using discriminate

analysis, it was reported that a-C18:3, C14:0, C17:0, SFAs, and MUFAs could potentially be five indicators for tracing the geographical origin of beef. The overall discrimination rate was 82.0% for their four geographical origin tests [38].

33.4.2.2 Trends in Food Origin Traceability Technology

With global attention focusing on food safety and product identification technology, food origin traceability technology has been researched and applied to a variety of animal and plant products. In recent years, there have been two new trends in the technological development of food origin traceability. One is the use of a strontium isotope for food origin traceability becoming increasingly prominent. The other is the analysis of changes in these traceability indicators during processing, to screen effective indicators for processed products, and expand the scope of application for geographical origin technology. Zhou *et al.* (2015) collected beef samples from three different provinces in China, and tested changes in $\delta^{13}\text{C}$, $\delta^{15}\text{N}$, and $\delta^2\text{H}$ in the meat after three processing methods: boiling, frying, and grilling. They found a significant impact on $\delta^2\text{H}$ but no significant impact on $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ [39].

33.5 Problems and Recommendations

33.5.1 Problems

First, there is a lack of uniform traceability standards and guidance, different traceability system architecture has been developed by different ministries, and tracing information cannot be shared and interconnected. The newly revised “Food Safety Law” proposed to establish a national food safety traceability system. To be in accordance with the provisions of this law, food producers shall develop safety systems to ensure that food is traceable. The state encourages food producers and traders to use information systems to collect and retain production and management information. Currently, there is a lack of standards and guidance on how to establish a food safety traceability system and of a state authority responsible for its development and management; there is also no unified platform to manage a food traceability system. Due to the lack of uniform technical standards and specifications, the current tracing methods are confusing, thus the current traceability system has become a common labeling system.

Second, there is a lack of product coding and basic information databases, making it difficult to collect food traceability information. In comparison with developed countries, China’s overall agricultural production is small in scale, with less intensification, standardization, and organization. About 200 million small-scale farmers in China use their own pesticides, veterinary drugs, and have their own fertilizer programs. Their production is in accordance with their wishes. Their products will be transferred between more than 30 million small traders, through the local intermediary and wholesale markets, before they are delivered to the consumers’ tables. In order to achieve traceability in agricultural cultivation, growth, and other aspects of production, information about fertilizers, pesticides, veterinary drugs, and production management, amongst others, must be fully recorded. Most Chinese farmers are not highly educated and have low professional knowledge. The high costs of information recording are not

welcomed by these farmers. Moreover, there is a lack of coding system and basic information databases for seeds, pesticides, veterinary drugs, fertilizers, and other agricultural inputs. Also, most products are not marked with a traceability code when they are shipped out of the plant, thus making the collection of source traceability information difficult.

Third, traceability systems, GAP, and HACCP are not yet closely related. Guidance for a traceability system for enterprise quality and safety management is not strong, the cost of establishing a system is high, and enterprises lack the motivation to develop and implement it, so the application rate of traceability systems is low. Currently, most of the food traceability indicator systems are not screened or determined by GAP and HACCP, so that key traceability information is missing. When food safety issues occur, the traceability system cannot play its role. Moreover, the development cost of a food safety traceability system is relatively high: companies not only need to invest in software and hardware requirements, but also need to send professionals to help them record the information, use the system, conduct regular staff training, change management concepts, and develop the habit of recording complete production process information. Businesses not only have to spend money, but a lot of manpower is needed, and implementation is a lengthy process. For low-margin industries such as the food industry, such a high cost of investment can be overwhelming for many small businesses. If the government does not have favorable policies, and the market doesn't have much demand, food companies have no incentive to invest in food traceability systems.

Fourth, consumer awareness of the value of a traceability system is low. Consumers are ultimately buyers of traceable foods, and their willingness to pay for traceable food determines the enthusiasm of food companies for implementing a food traceability system. Although the system will increase certain costs for the enterprises, if consumers are willing to pay higher prices, manufacturers could produce traceable food at certain scales to meet this consumer demand, thus improving system utilization, reducing marginal cost for traceable products, and creating larger revenue. Conversely, if consumers are not willing to pay more for traceable food, and the government does not provide favorable policies and economic support, then enterprises are unlikely to want to adopt the system. A survey found that consumer awareness of food traceability is very low. Another survey also showed that only 3% of people are very familiar with the food traceability system; even in Beijing city where there is a relatively high awareness of food traceability, some pilot house staff did not have good understanding of it.

Last, information security and anti-counterfeit measures are poor. Information technology provides tools for developing a food traceability system, but like any other network information, there is the danger of viruses like Trojan horses and other erosion, resulting in the loss of information, theft, tampering, and other issues. There is also the risk of leakage of confidential business information. For bar codes and two-dimensional codes, risks include wrong coding, copying, and piracy. Currently, cases occur frequently where two-dimensional code scanning either does not come out or food traceability information does not exist. Consumers have more concerns about whether the source of information is true and reliable and the information complete, than trusting the traceability system itself.

33.5.2 Recommendations

33.5.2.1 Establish and Improve Food Safety Traceability Regulations and Standards

The government's primary responsibility in the development of food safety traceability systems is to enact laws and regulations, develop standards and related management systems, and to provide guidance on implementation measures in agricultural production, processing, and distribution. Currently, the regulations on implementation of food traceability are not comprehensive, there is a lack of traceability guidance, of specifications, and standards for recording information in a traceability system. Lack of coding specifications, basic information databases, and other prerequisite work for agricultural inputs and food need to be further strengthened and improved.

33.5.2.2 Strengthen Top-Level Design and Build a Unified Information Platform

A food safety traceability system requires interoperability information, unified planning, and design from the national level. It requires a unified information-recording system, a unified modular design, a unified data format, and a unified coding system to achieve the goal of communication and exchange of information through the whole food chain.

33.5.2.3 Promote the Standardization and Intensification of Agricultural and Food Industries

Agricultural production in small-scale operations, dispersed cultivation, and diversification of sales channels are the main factors restricting food traceability system development. Chambers of Commerce, agricultural production cooperatives, and leading enterprises of agricultural production and distribution need to play a leading role of driving food traceability systems and applications.

33.5.2.4 Establish a Scientific Supervision and Management System and Promote an Enterprise Credit System to Guarantee the Authenticity of Traceability Information

The key to food traceability development is to guarantee continuity and authenticity of the traceability information in the chain. We need to continue to research and develop key traceability information indicators, such as origin, variety, species, and other identification and validation technologies, strengthen the supervision and management system, and continue to improve and perfect the integrity of the system in food companies, preventing phenomena such as false information and traceability tampering, to improve the credibility of traceability information.

33.5.2.5 Enhance the Information Level of Agricultural Infrastructure

The cost of developing a food traceability system is relatively high, but agricultural and food industries have relatively low profits, which results in a lack of motivation to develop a traceability system among agricultural and food production enterprises. Governments need to provide special funds to support the development of demonstration bases for food traceability systems, while providing hardware, equipment, technical training, and other support for food businesses or other industrial organizations.

33.5.2.6 Strengthen the Convergence of Networking Technology and Traceability System Development

Sensors, big data, cloud computing, RFID, and other advanced technologies need to be taken full advantage of to exploit their intersection with agricultural product logistics and food traceability, solve technical problems such as timely information collection, transmission, and exchange in food traceability, and ultimately interact with the relevant parties.

33.5.2.7 Intensify Publicity Efforts to increase Consumer Awareness

The government should publish objective information through the media, in order to strengthen information release on food safety where consumers have concerns. They should publish timely information on the status and applications of food traceability systems, increase the consumer awareness level and interest in traceable food, and expand market demands for traceable food, thereby reducing cost pressures and encouraging more enterprises to actively develop food traceability systems.

A food traceability system is a comprehensive system that needs advancement from government regulation, corporate integrity, and consumer recognition. With larger agricultural production scales and speeds, and the rapid development of information technology, food traceability systems in China will embark on a new stage in 2020.

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