A Review of Food Safety Research in China

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The Chinese government has created a vital special report entitled "Key Technology of Food Safety." This report is concerned with food safety problems during China's tenth five-year plan and the government's commitment to invest up to 150 million RMB. This report focuses on the core goal of ensuring the health of Chinese consumers and protecting the safety of the Chinese food import and export trade. It points to international science and the technology frontier of food safety, grasps the key links and bottlenecks in comprehensive control of Chinese food safety, and looks at integrating advantageous scientific resources within the country and conducting "breakthrough" studies.

Result and Effects of the Report's Implementation

The report describes the accomplishments over five years of implementation toward each expected objective of the food safety index: setting up two national networks (the national surveillance network for food contamination and foodborne disease and the surveillance and prealerting network for import and export food safety); setting up and revising 40 national standards and 166 technical and regional standards; applying 385 standards (two of which are international standards that involve 595 proposed values of maximum limits and 58 practice Codex guidelines in the field of production and circulation); developing 219 analytical methods (especially multiresidue methods for 150 pesticides and 122 veterinary drugs); developing 81 test-kit techniques and fast onsite detection techniques, as well as 25 pieces of related equipment; applying for 128 national patents; and authorizing 36 patents. Moreover, three national institutions have increased their capacity, and 168 analytical laboratories have participated in an international proficiency test and received accreditation by related international laboratories. Demonstration models of food safety have also been built in 10 areas, involving 219 enterprises.

Of the eight achievements cited by the report, the first is that the ability of Chinese food safety workers to introduce independent scientific innovation has been enhanced. The second is that Chinese food safety has been accelerated through the improvement of the scientific and technological support system. The preliminary standards of the food safety support system have been formed. Inspection and detection systems under Chinese supervision have been set up, scientific and systematic supervision systems have been improved, the rudiments of an efficient, prealerting information system have already been formed, achievements in systematic and standardized safety production systems have been displayed, multilevel and multichannel teaching and training systems have been created, and, finally, public consciousness of food safety has been increased greatly.

The third achievement is that the whole level of Chinese food safety has been raised. The production and circulation of food safety is more standardized. The food safety index has been enhanced, and the ability to deal with unexpected incidents has been strengthened over time. The fourth achievement is support for the development of key regional industries. The core competence of the industry has been strengthened, and the brand effect of a series of food companies has been greatly enhanced. The fifth achievement involves the creation of a scientifically innovative team with increased levels of inspection and detection; supervision and management of the team have also been supported.

The sixth achievement is that public food safety research institutions have been enlarged. The initial scale of research and development institutions has been established. A series of newly created scientific food safety bases has also been established, and a preliminary scientific food safety innovation system has been set up. The seventh achievement is that the scientific and technological work of local food safety experts has been strongly promoted. The creation of scientific food safety issues by local governments has been exciting, and the development of local food safety inspection and research institutions has been accelerated. Finally, the eighth achievement is that nine characteristic demonstration food safety models have been formed, including Jiangsu Suguo Supermarket (relying on its own guard); Shanxi Luochuan Apple (highlighting control of input products, such as fertilizers and pesticides); Fujian Yinxiang Pork (comprehensive quarantine); Guangdong Hengxing Aquatic (strictly guaranteeing export quality); Henan Hebi Wheat (planting and processing safety); Shandong Shouguang Vegetables (led by government and socialized by the regional economy); Qingdao Restaurants for Olympic sailing games (guaranteeing the safety of vital activities); Zhejiang Longjing Tea (highlighting the choice of bases); and Beijing Logistics (emphasizing distribution safety control).

New Food Safety Technology Horizons—Efforts to Improve Chinese Innovation

The establishment of an international standard for Production Specification of Preventing and Reducing the Aflatoxin Pollutants in Vegetables and Fruits was led by China. As head of the drafting group, China developed the food additives procedure for the standard. China was named the national chair of the special Committee on Food Additives and Pesticide Residues of the Codex Alimentarius Commission (CAC). (The CAC was created in 1963 by FAO and WHO to develop food standards, guidelines, and related texts, including codes of practice under the Joint FAO/WHO Food Standards Programme.)

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Ultratrace analysis of dioxin and dioxin-like polychlorinated biphenyls (PCBs) represented the analytical level of a country. Today, there are only a few labs in developed countries that have the ability to analyze PCBs. The ability of participating countries to conduct verification tests is the only way that an ultratrace analysis lab may achieve international accreditation. The Nutrition and Food Safety Institute of the Chinese Center for Disease Control and Prevention led related units in China in participating in verification tests eight times, passing with an excellent performance. It became the constant values lab for international standard materials, significantly increasing the international position of Chinese science and technology in food safety. China then drafted the CAC international standard for dioxin and will host the international annual meeting on dioxin in 2009. China also participated in drafting the international standard for dichloropropanol limes. This resulted in the receipt of the second prize for the Chinese Medical Science and Technology Award in 2005 and the second prize for the Chinese National Science and Technology Progress Award in 2006.

A great breakthrough in the development of food safety detection equipment has also been made. An organotin detector, a flame photometric detector using quartz surface-induced luminescence, has been successfully developed by the Ecological Environmental Research Center of the China Academy of Sciences. The organotin detector has an increased detection sensitivity of 100- to 1,000-fold and was granted the second prize in Chinese National Natural Science. In addition, a food safety monitoring mobile unit with multiple patents and detection technologies has been developed by the Scientific Research Institute of China Detection and Quarantine. This has become a mobile food safety detection lab. There are 22 units equipped with quality and industry monitoring systems, and an additional 10 units will be equipped; the units made a profit of approximately 200 million RMB and played an important role in real-time monitoring of environmental pollution of the Songhua River in 2006 (1). In order to guarantee import and export trade safety of poultry, the Exit-Entry Test and Quarantine Bureau of Beijing and the PG Biotech Company have jointly developed a multiplex real-time reverse-transcriptase PCR (RT-PCR) kit for the rapid detection of subtypes H5, H7, and H9 of the avian influenza virus, which decreased the detection time from 21 days to 4 hr. They also set up four national standards and certified a new type I veterinary drug. The number of kits increased in exit-entry tests and quarantines from 2004 to 2005 to approximately 200,000 pieces, playing an important role in guaranteeing the exit-entry trade safety of Chinese poultry products.

Merging Modern and Traditional Technologies

Looking at the present status of Chinese technology, one can see incomplete and dispersed inspection methods, outdated food safety inspection technology, nonavailability of some biotoxin standards and pathogenic strains prohibited by embargo blockades, and the merger of traditional physicochemical inspection technology with modern technology (i.e., biotechnology, nanotechnology, and information technology). A series of rapid selection methods that have urgently been needed for food safety supervision and law enforcement in China have been developed. Detection and quarantine systems based on Chinese conditions and international practices have also been created. For example, a detection system has been set up for major food microorganisms, including *Vibrio cholerae,* pathogenic *Escherichia coli, Campylobacter jejuni, Yersinia enterocolitica, V. parahaemolyticus, Salmonella, Staphylococcus aureus,* and *Shigella*.

Standardized probe and chip preparation methods have been improved and have made an excellent foundation for studying high-flux detection technologies for detecting foodborne viruses. Research platforms for molecular detection of plant pests have been successfully built up to continue rapid-detection research on high-risk pests. Detection methods for bovine-, sheep-, and goat-derived materials in food and feed, along with molecular marker identification techniques for another seven types of mammals, have been created. Additionally, a gene-chip identification method has also been developed. The newly developed veterinary drug residual-protein chip technology is used around the world. Through RT-PCR detection technology, rapid inspection methods for both domestic animals and humans infected by diseases, including Newcastle disease, foot and mouth disease, and vesicular stomatitis virus, have been created, shortening the detection time greatly. A patent application has been made for this technology. Currently, the kit is assembled, batch produced, and locally used, so it requires further verification to establish a Chinese national standard.

Due to embargo blockades, biotoxin standards (e.g., aflatoxin B1 and tetrodotoxin) are not available. As a result, studies using anti-idiotype antibodies to stimulate external antigen epitope to substitute for toxin standards have been conducted, and nontoxic immunoassay reagent kits for aflatoxin B1 and tetrodotoxin, which have independent intellectual property rights, have been created. Patulin pollution of apples and its products affects apple juice exports. Although there have been no breakthroughs in this area, three approaches have been studied: antitoxic monoclonal antibody, positive bacteriophage cloning, and bacteriophage mycotoxin stimulation epitope peptide selection, among which selection methods of stimulating epitope peptide have provided a new way to set up an immunoassay method for patulin.

Advancing the Development of Food Safety Science and Technology

In order to overcome the problems of outdated detection technology and long development periods in China as quickly as possible, the report calls for the strengthening of systems for the introduction and integration of new technologies, as well as the redesign of existing technologies to promote food safety testing and detection abilities in China. The number of pesticide residue detection tests for varieties of rice and tea required by Europe and Japan exceeds 100. Aiming to meet the time requirements for customs clearance and the requirements for chromatography and mass spectrometry confirmation technology, a series of pesticide and veterinary drug multicomponent residue detection technologies for food have been developed. Using the multicomponent residue detection technologies adopted in Europe and the United States, a redesign of the technology has been completed, and pesticide residue detection technologies using GC-MS, LC-MS have been explored. The result may be that the number of pesticide residue detection tests for varieties of rice and tea could exceed 150, breaking through the bottleneck created by the limitations of the current food safety detection system in China.

During the process of creating detection technologies for dioxin, PCBs, dichloropropanol, acrylamide, nitrofuran marker residue, and hormones, an isotopic dilution mass spectrometry technique has been introduced as the international "gold standard" according to international experts. In addition, a modified ultratrace detection technique for important organic pollutants that is aligned with international practices had been established. For example, a detection method for dioxin and PCBs has been created that integrates the original two methods into one, greatly enhancing the ultratrace detection level of organic pollutants in foods. A series of modified pretreating techniques has also been created. For instance, studies of analytical technologies and the independent development of fiber extraction were actively pur-

sued once solid-phase microextraction had been introduced to food safety detection. An immune affinity column for total aflatoxin, aflatoxin B1, zearalenone, ochratoxin A, and deoxynivalenol; an avermectin molecularly imprinted column; and a solid-phase extraction column for aminoglycoside have also been prepared. It was through the use of matrix dispersion and microwave extraction techniques that the challenge of determining fat- and water-soluble components simultaneously was solved. As soon as a special algae lab has been founded to isolate, purify, and obtain 5 mg of paralytic shellfish poisoning toxins and 500 mg of microcystic toxins as standards, the chromatography-mass spectrometry analytical method was used to detect microcystic toxins, paralytic shellfish poisoning toxins (PSP), amnesia shellfish poisoning toxins (ASP), diarrhetic shellfish poisoning toxins (DSP), and palytoxin (PTX). This has led to the removal the embargo blockade of China.

Research on rapid detection techniques is recognized as vital to food safety in this special report. Currently, 81 types of food safety detection reagent kits have been developed. These kits are used to detect pesticides, veterinary drugs, biotoxins, food additives, feed additives, prohibitive chemical residues, and animal and plant pathogens. Ninety-four food safety rapid detection and verification methods have been established. Twenty-five types of detection equipment have been designed. Altogether, developments include 13 types of rapid and efficient biotoxin (ochratoxin A, T2 toxin, aflatoxin B1, total aflatoxin, zearalenone, fumonisin B1, deoxynivalenol, tetrodotoxin, PSP, ASP, DSP, PTX, and microcystic toxins) immunoassay reagent kits with independent intellectual property rights; five types of immune colloidal gold test papers (aflatoxin B1, ochratoxin A, zearalenone, deoxynivalenol, and citrinin); six types of ELISA kits for pesticide residues (metalaxyl, methamidophos, chlorpyrifos, parathion, 2, 4-D butyl ester, and chlorothalonil); 16 types of rapid colloidal gold immunoassay test papers (3,5,6-trichloropyridin-2-ol, benomyl, bromacil, butachlor, chlorpyrifos, diclofop-methyl, alachlor, carbaryl, metalaxyl, propamocarb hydrochloride, simazine, bromoxynil, acetochlor, propisochlor, metolachlor, and atrazine); and 11 types of ELISA kits for veterinary drug residues (avermectin, clenbuterol, furazolidone metabolites 3-amino-2-oxazolone, zeranol, chloramphenicol, sulfamethazine, 19-demethyl testosterone, diethylstilbestrol, hexestrol, medroxyprogesterone acetate, and chlortetracycline).

Most of these achievements have already been popularized and are used in China. Test kits for avermectin, sulfamethazine, and clenbuterol have been industrialized. A number of them are used as alternatives to their corresponding imported product, which decreases the test costs greatly and achieves a significant economic and social profit. The Rapid Detection Equipment for Series of Food Safety is portable and can be used in situ to confirm the safety of foods and to detect common food contaminants. This equipment can also be used to investigate and verify the causes of military and local food poisoning outbreaks.

Prospects for Food Safety Science and Technology in China

During the eleventh five-year plan, food safety science and technology will be listed as vital items in the National Scientific Supporting Plan in China (NSSPC) in order to strengthen the independent creativity of food safety science and technology and to support supervisory aspects in China. Some breakthroughs are expected in the areas of risk evaluation, detection and monitoring, traceability, and prealerting. Test method selection and equipment development should be intensified. A standard food safety system should be completed. Tactical research on food safety and international cooperation should be developed. The transition from passive coping to active guaranteeing should be realized gradually. In China, hazard analysis, prealerting, and a rapid response platform for pathogenic microorganisms, pesticide and veterinary drug residues, chemical pollutants (including biotoxins), food additives, and food packaging materials should be set up. Moreover, four to five risk evaluation centers for food hazards will be constructed in China. Work on 150–200 detection methods and the establishment of standards should be completed, and 15–20 types of standard materials should be prepared.

It is vital that techniques for multiple residue treatment and metabolic characterization of a series of food hazards, food attribute characterization, rapid and high-flux detection, rapid testing, and obtainment of evidence in law enforcement, as well as the corresponding equipment, be developed. Comprehensive monitoring, traceability, and rapid prealerting systems should be further improved. Ten dynamic databases will be founded that incorporate more than 500,000 pieces of data. A qualified food safety evaluation system should be further refined. Five to ten comprehensive model zones for demonstration should be set up. Currently, there are 20 programs deployed in connection with vital items listed in the NSSPC as part of its eleventh five-year plan, and these items are continuing to be upgraded to vital special items.

Reference

1. It's a chemical pollution incident in the Songhua River tributary called Mangniu River. The major pollutant is xylidine, which were illegally discharged by a local chemical company.

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