Research on the Food Safety Supply Chain Traceability Management System Base on the Internet of Things

Kefei Liu

Henan University of technology
908809047@qq.com

Abstract

The food security relates to the people's health and is the top priority in the daily lives. In this paper, in order to solve the food security problem, we propose the food safety supply chain traceability management system which is based on the Internet of things. Through the relevant application of the RFID technology, we establish the effective food safety supply chain traceability management system. It not only can supervise the food from the source, but also makes the internal rights of the food supply chain clear. Once appearing the food security accident, using the system can help enterprises to supervise the production process of the food effectively, identify the cause of the problem and find out the source of the problem. The application of the system can protect the food security better and enhance the security sense of the consumers.

Keywords: The Internet of things, RFID, food safety supply chain traceability management system

1. Introduction

With the frequent food security accidents in our country, the majority of consumers are getting more and more attention to the food security problem. It can trace and manage the food security problem effectively to establish the food security traceability system. The construction of the food security supply chain traceability management system has become an important measure for ensuring the food security.

Along with the continuous improvement of the food and agricultural product quality for the consumers, it is more and more urgent to monitor the food supply chain and trace the food demand. It is an important measure to use the Internet of the things technology to construct the food supply chain traceability system.

Food traceability has attracted the attention of many scholars and achieved fruitful results [1-5]. Su Pin studied the agricultural product quality security traceability system which was based on the multi-agent. Synthesizing the artificial intelligence, intelligent control and the measurement technology, he put forward the agricultural product quality security traceability system which was based on the multi-agent [6]. Kong Dawei studied the food traceability system which was based on the supply chain. Fei Yali studied the quality security traceability system of the government mandatory pork [8]. Zhao Li designed the agricultural product quality security traceability system which was based on the mobile phone of the 2D bar-code recognition. The test results showed that the system could make the user quickly identify the 2D bar code label of the producer. It provided the new trace-mean for the consumers [9]. Wu Wei established the chicken quality security traceability system which was based on the RIA technology. The author developed the agricultural product quality security traceability system which was suitable for the chicken industry chain based on the technology and the application development framework. It achieved the information traceability for each link of the chicken

industry chain [10]. Huang Hailong established the agricultural product quality security traceability system based on the NET technology. The author used the ASP.NET technology and AJAX technology to establish the development of the agricultural product quality security traceability system which was based on the Visual Studio 2005 and SQL Server 2000 [11]. Chen Fang and Zhang Qijun studied the food security traceability system based on the asymmetric information and used the food traceability system to solve the problem of the asymmetric information [12]. Through the analysis of each link for the food supply chain, Liang Pingzheng proposed the standard three-dimensional coding scheme which was accorded with the EAN.UCC. And he constructed the information system which supported the whole process tracking of the food supply chain [13]. Yuan Tao proposed the whole framework of the agricultural supply chain traceability system, discussed the information acquisition technology to construct the system, collect and transmit the information of each stage [14].

In this paper, we proposed the food safety supply chain traceability management system which was based on the Internet of the things. By the application of the RFID technology, it can trace the food effectively, reduce the possibility of the food security accidents, make the clear responsibility and enhance the confidence of the consumers. The structure of this paper is as follows. The first part is the introduction. The second part is the theoretical foundation of establishing the food traceability system. In this part, we introduce mainly the related concepts of the food supply chain, the current situation of our country's food and the necessity of establishing the food security supply chain traceability management system. The third part is the food security supply chain traceability management system based on the Internet of thing. In this part, we apply the RFID technology to establish the food security supply chain traceability management system. The fourth part is the technical scheme of food security supply chain traceability management system. It mainly introduces the technical scheme of food security supply chain traceability management system. The last part is the conclusion.

2. The Theoretical Foundation Of Establishing The Food Traceability System

2.1 Food Supply Chain

When the concept of the supply chain management was successful to apply to the operation and management of various companies, the food industry and the agricultural products also followed this trend. They introduced the concept of the supply chain management to their own industries in order to improve their own competitiveness. Represented by the Zuurbier, the foreign scholars put forward the concept of the food supply chain which was based on the general supply chain idea in 1996. At the same time, they also gave a specific definition of the food supply chain management. That is, the food supply chain is the vertical integration operation mode that the organization of the agricultural production and the production sales used. They operated this mode in order to reduce the logistics cost of the food and the agricultural production, and improve level of the quality security and the service. After the concept being proposed, some developed countries, such as American, France and Canada, introduced and popularized the mode and achieved good practical results. At the same time, this management mode gained gradually the attention of the scholars in the world scope. Then it becomes the popular topic.

The cause of the food supply chain management is that the requirement for the production is improving continually. In general, the reason can be classified into the following reasons.

Firstly, the requirement of the consumers for the food is getting higher. With the improvement of the life quality level, the consumers have a higher requirement for the quality of food. The quality of food not only reflected the freshness, but also the nutrition, safety and health. The basic problem that the consumers consider is where we can eat the safe and nutritious food.

Secondly, the consumers pay more and more attention on the quality security of the food. In order to satisfy the need of the various fresh foods and keep the food fresh, more and more science technologies are applied to the food field, such as pesticides, antibiotics and GM etc. The application of these technologies meets the requirement of the consumers. However, it also harmed to the human body. With a series of food safety incidents, the consumers pay more attention on the food security. The future development direction is to establish the transparent regulatory system and let the consumers know the quality check result from the farm to the table.

The third reason is the legal requirement. In order to protect the citizens' personal health and the long term development of our country, the countries around the world had developed the food quality security supervision laws. With these legal constraints, the food enterprises must be in accordance with the process of the food supply chain to product the productions.

The fourth reason is the operation cost of the supply chain. The development trend of the modern enterprise has the higher and higher requirement for the supply chain. Due to the special nature of the food supply chain, the response time is much faster. Due to the reduction of the response time, the operation cost of the food supply chain is much higher. In order to reduce the costs, the food enterprises must introduce the supply chain management strategy.

2.2 The Special Nature of the Food Supply Chain

The response time of the food supply chain is faster. This makes the difference between the food supply chain and supply chain of other industries. The food supply chain has its own unique. The specific performance is as follows.

Firstly, the outsourcing proportion in the management process is bigger. Because the output value of the food and the agricultural food is lower, especially the products which are belonging to the fast selling properties, the manufactures will outsource the related business and do not establish the system in order to reduce the logistics cost.

Secondly, the turnaround time from the production to consumption for the supply chain product is short. However, the food supply chain has many links. For the food and agricultural products, from the production, processing, sales to the final consumption, in order to ensure the freshness and seize the market, the time requirement is very high. However, at the same time, it needs many operational links. In a number of links, each link must be careful in order to ensure the quality security of the final consumer products. When the food supply chain designs and operates, it must be high efficiency. At the same time, each link must ensure the food quality security.

Thirdly, the cycle of the supply chain product is short. It has the very high requirement for the inventory allocation, product transportation and channel management. Therefore, it relies on the information technology. The channel ability is a kind of ability which is lasting, cannot buy, cannot transferable and is related to the current market capacity. The channel ability is often the core competitiveness of the food enterprises. Through the perfect information technology, the enterprises can achieve the timely communication with the channel partners, set the channel inventory effectively. Finally, it achieves the product supply under the saving of the supply chain.

Fourthly, it has the strong dependence on the cold chain technology. The purpose of the cold supply chain is to ensure the quality of the perishable and keep the low temperature environment. This not only has the technical requirement for the cold supply

chain transportation system, but also has the controlled cooling technology for the cold storage facilities. Then it can ensure the quality and security of the products for the final consumption food.

Fifthly, there are many competitors among the lateral supply chain. The loyalty of the consumers for the products is not high. This requires the food supply chain management must ensure the quality security. At the same time, it must consider the effects of various promotions and advertising on the consumers. Then it can add the supply chain value.

In general, the food supply chain composes of different links and organizations. It concludes the prenatal seed, feed production (seed, feed suppliers)-the production of planting and breeding industry in production (farmers or producers)-post classification, packaging, processing, storage, sale and other links. In foreign countries, this structure is called as seed-food. In China, we call it "from the farm to the table".

2.3 The Current Analysis of the Food Security in China

China is a large population country. This characteristic makes our country have a great demand for food. These requirements rush the industry development for our country. At the same time, it promotes some traders do the illegal behavior and causes the food poisoning. According to the bulletin of the national food poisoning events which is released by the emergency command center committee office of public emergencies in National Health Family Planning Office, we analyze the food security situation for the recent 10 years.

Table1. Food Safety Status

year	The number of report	The number of poisoning	The number of death
2004	397	14586	282
2005	256	9021	235
2006	596	18063	196
2007	506	13280	258
2008	431	13095	154
2009	271	11007	181
2010	220	7383	184
2011	189	8324	137
2012	174	6685	146
2013	152	5559	109

From the Table 1, we can see that the number of poisoning and death has a certain degree of decline in the report of the food security accident although the crackdown increasing in recent years. However, in 2013, there are still 109 persons died. The overall situation of the food security has improved. However, the situation is still grim.

Then, we analyze the situation of the food security in 2013 which is shown as Table 2

Table 2. Situation of the Food Security in 2013

year	The number of report	The number of poisoning	The number of death
January	12	399	8
February	5	154	5
March	8	205	6
April	9	282	9
May	13	494	8
June	17	718	8
July	22	293	27

August	18	609	12
September	21	1131	6
October	7	521	5
November	11	469	7
December	9	284	8
Total	152	5559	109

In 2013, the reported food poisoning incidents have 152. There are 5559 people poisoning and 109 people death. Compared with the same period in 2012, the reported number reduces 12.6%. The number of poisoning people reduces 16.8% and the number of the death people reduces 25.3%. In 2013, there is no major or above level food poisoning reports. The higher level food poisoning reports are 76. And there are 1099 people poisoning and 109 people death. The first class food poisoning incident reports have 76. There are 4460 people poisoning and no people death. In the food poisoning incident report of 2013, the incident number of the third quarter is the highest. The death number accounts for 40.1%, 36.57% and 41.28% of the total. The most reported number and death number is July. It accounts for 14.47% and 24.77% of the total. The most poisoning number is September. It accounts for 20.34% of the total. Facing the severe food security situation, it is necessary and urgent to establish the appropriate food traceability system.

2.4 The Food Traceability System

The foodborne malignant events outbreak frequently in the worldwide especially the Europe BSE crisis. In the background, the food traceability system is proposed. It is proposed by the French and other EU countries in the international food codex committee on food biotechnology special intergovernmental working group meeting. It aims to strengthen the food security information transmission, control the harm of the food borne disease and protect the information recording system of the consumer interests.

The function of the traceability system has three aspects. The first is the flow tracking. It is used to recall and process the products which exist the quality security problem. The second is to trace the source of the problem. It invests the links which may have the quality problem, finds out the reason and the responsibility. The third is the logistics management. The traceability system integrates the seven functions of the logistics transportation, storage, distribution processing, distribution, handing, packaging and the information processing etc. It optimizes the business processes and promotes the integrated management of the supply chain.

2.5 The Necessity to Establish the Food Traceability System

The food security problem is sensitive issues that the vast number of consumers concerns. From the early Sanlu milk power incident to the later drainage oil and Husi event, a series of food security accidents affect the consumers. At the same time, it hits the trust for the food security of the consumers. In order to restore the consumer confidence, the major food companies begin to pay attention to the quality supervision. One of these measures is to establish the food traceability system. According to the food traceability system, the food enterprises and the consumers can reduce the potential loss maximum which is caused by the defects of the food quality security system. At present, many countries have begun to use the food traceability system to reduce maximum the defects of the food security system and the potential loss which is brought by the defects. Due to the establishment of the food traceability system, once the consumers find the food security problem, they can use the food traceability system to search and find out the problem from the source. In this way, it has the huge blow for the illegal behavior of the food enterprises. In addition, if the food industry find food security questions and these

problems will bring the huge economic losses, they will take the appropriate measures to eliminate the security problems in order to avoid the negative impact for the enterprises themselves or the brand which are caused by the food quality security problems. In general, the necessity to establish the food traceability system has the following several points.

Firstly, the food security problem of our country is still outstanding. In recent years, food security problems in China are still very prominent, such as drainage oil event and Fuk meat event etc. The continuous exposure of the food security problems causes the whole society attention. In order to strengthen the control for the food security problem, it is necessary to establish the appropriate food traceability system. The food traceability system not only can ensure the food security, but also can determine and divide the responsibility of the food security problem. At the same time, as a kind of constraint system, it ensures that each link can strengthen the food quality security. Therefore, in the situation of food security problem becoming increasingly prominent case of our country, the pressing matter of the moment is to strengthen the food supply chain supervision.

The second is to increase the confidence of the consumers. With the establishment of the food traceability system, the consumers can know more detail information of the food in each supply chain link. The establishment of the system can not only provide the detailed information of the supply chain to the consumers, but also can promote the food enterprise to improve the production technology and improve the product quality constantly. In this system, the consumers can search the food security information and carry out the supervision on the food enterprises. It enhances the confidence of consumers in food security.

The third is to reduce the operational cost of the food supply chain. Due to the characteristics of this food, the food is easy to decompose in the transport process. According to the food traceability system, we can monitor effectively the transportation state of the food, reduce the food decay rates. So, we can reduce the operational cost of the food supply chain.

The fourth is to comply with the international trend and strengthen the international competitiveness. Since China joined the WTO, it is closer to other countries in the economy. And the import and export of the food is more frequently. In foreign countries, especially the European Union and Japan, they have the closely relate to our country. And these countries set up the food security traceability system. In order to comply with the international trend and strengthen the international competitiveness, we must establish the food security traceability system.

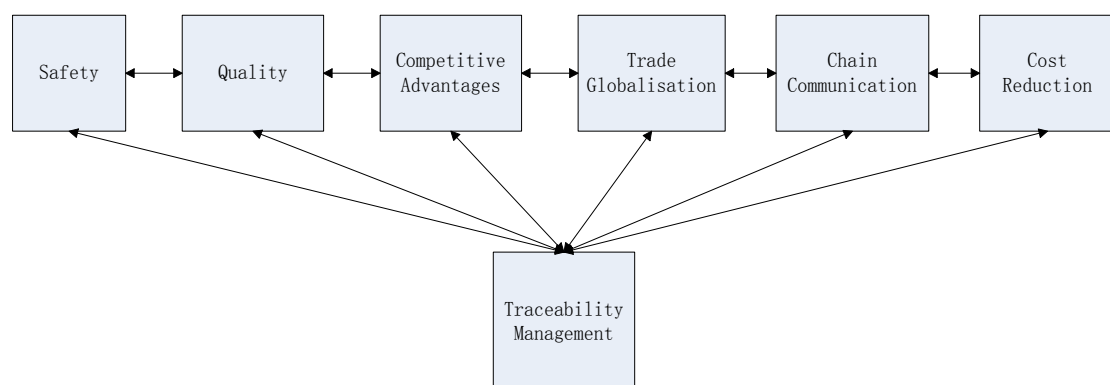We neaten the driving force of the food traceability system which is shown in the following Figure 1.

Figure 1. The Driving Force of the Food Traceability System

3. Food Safety Supply Chain Traceability Management System Based On the Internet of Things

3.1 Definition and Background of RFID

RFID is the radio frequency identification technology which is based on the Internet of things. RFID tag is the most important part of the technology. The tag contains two parts. One is the integrated circuit. Its main function is the storage, processing information, modulating, demodulating the radio frequency signal and other functions for the electronic product code (EPC). The other function is to receive the antenna and transmit the signal. EPC standard is developed by the Auto-ID center and composed by five famous universities, nearly 200 leading retailers, manufacturers of the consumer products and many the software companies.

The types of RFID tags are three kinds. They are active RFID tag, passive RFID tag and battery assisted passive RFID tag. Active RFID tag contains a battery. The battery can transmit signals independently. Passive RFID tag has no battery. And it needs an external source which uses to cause the signal transmission. Battery assisted passive RFID tag needs an external source to wake up. Therefore, it has the higher link performance and can provide a wider range.

RFID technology is often used to identify and track the products, animals and the people. Compared with the traditional bar code basis, the RFID technology can provide more useful information. For example, the place manufacturing place, the product components and the effective period of the product. In addition, unlike the bar codes, the RFID technology does not need to scan code. RFID uses the special RFID reader and special tags which attach to the object and uses the frequency signal to transmit the information to the RFID reader.

The RFID tags can provide more information than the traditional bar code. For example, the RFID tag not only tells us that what are the products, but also tell us the place manufacturing and the composition. The other advantage is, unlike the bar code, the needed sight scanning can read line. The RFID tag can also be as the passive tracking equipment. When RFID tag broadcasts the radio frequency, it is though a special scan code. RFID frequency serves technology is as a kind of the automated information processing technology. Compared with the code technology, it has a large amount of information storage, a long distance of reading and writing and it is convenient operation. It has more and more widely applied in animal individual identification, anti-counterfeiting, access control system and highway toll management. The market share is expanding increasingly. Its working principle is shown in the following Figure.
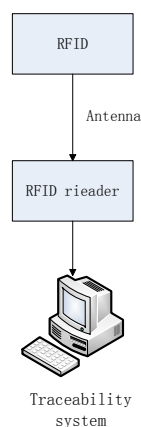

Figure 2. The Working Principle of Rfid

3.2 RFID Application Strategy in Agi-Food Supply Chaini

In the application of the food traceability system, RFID technology has its own special advantages. In food traceability, according to the automatic data acquisition, the technology can improve the highly accurate data. It improves the security and the efficiency of the food chain. In the process of the food transportation, because the food is sensitive to the temperature, using this technology can implement the visibility transport; reduce the food corruption, pollution and food borne diseases in the thermal transport conditions. On the other hand, using the technology can carry out the real-time tracking for the food and improve the productivity. The workers no longer need to write information manually. And it reduces the shrinkage and increases the efficiency of the supply chain. In this paper, we propose a food safety supply chain traceability management system based on RFID.

In this paper, we propose a Food Safety Supply Chain Traceability Management System which is based on the RFID technology. In food safety supply chain traceability management system, the consumers, the supply chain enterprises and the regulators can get the food information through the only global traceability code which is contained in the RFID tag. From the produce to the consumers, the food processing and transport information can obtain through the RFID tag. Therefore, we can get the purpose of chain traceability. The food safety supply chain traceability management system is established. The frame of food safety supply chain traceability management system is shown as the Figure 3
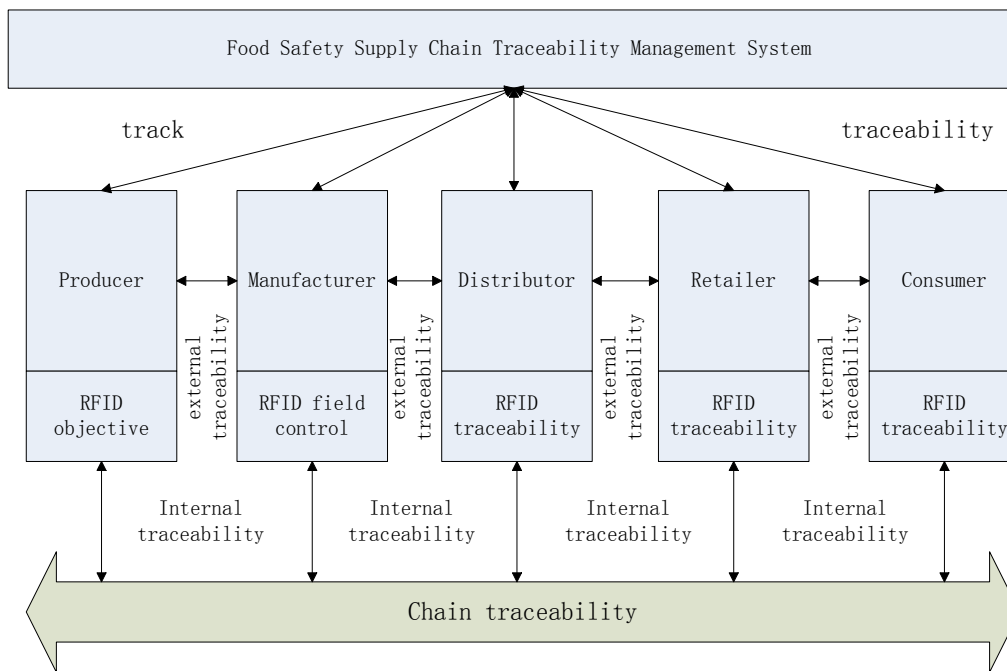

Figure 3. The Frame of Food Safety Supply Chain Traceability Management System

4. The Technical Scheme of Food Safety Supply Chain Traceability Management System

When the reader receives the command and begins to work, the reader sends the command of the food RFID tag to the antenna. After the RFID tag in the food receives the radio waves which send from the antenna, it sends the serial number information. After the antenna receives the signal, it transmits the information to the reader. The reader processes the received signal. Then, the reader transmits the signal to the data processing

ship in the reader. At the same time, the sensor will transmit the information which is around the food to the data processing chip. The data processing chip carries out the comprehensive treatment for the received information. Then according to the Internet, it sends the processing results to the food security database. When the user logs to the food security supply chain traceability management system to query, the information in the database will transmit the information to the food security supply chain traceability management system. Then it transmits the information to the users. The technical scheme of food safety supply chain traceability management system is as Figure 4.
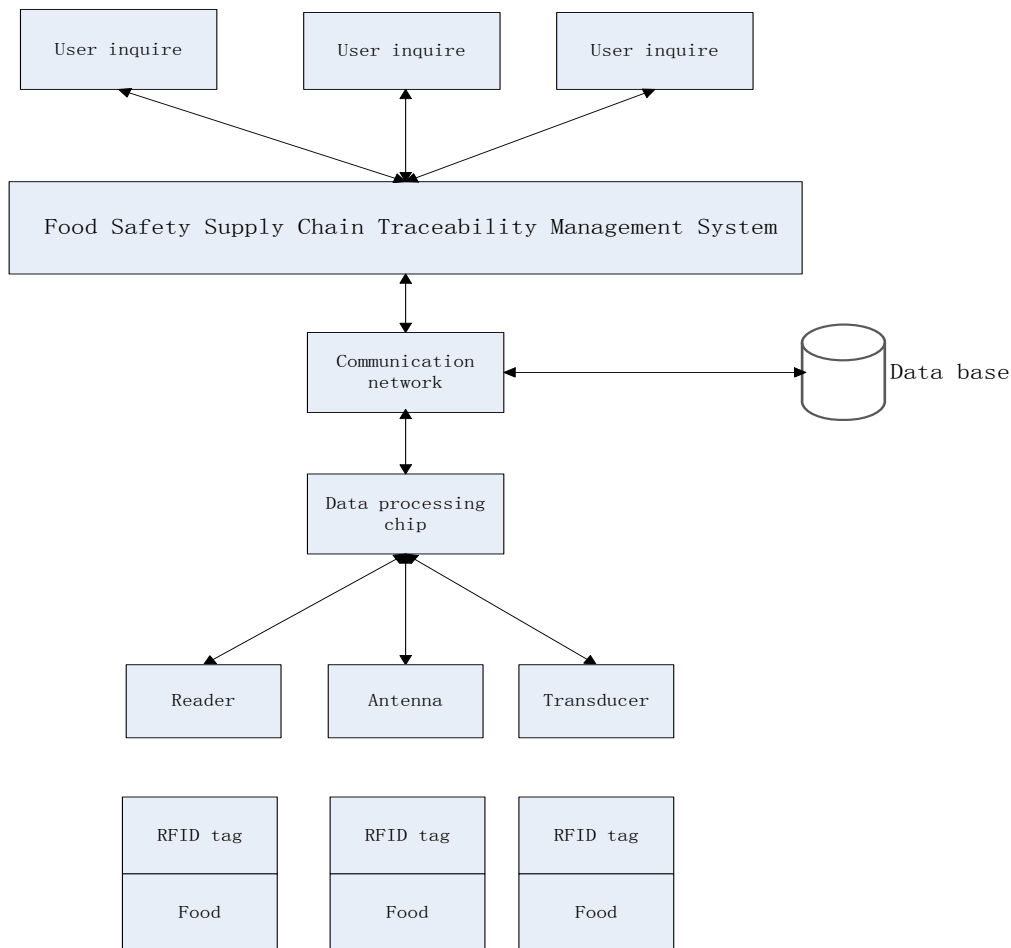

Figure 4.The Technical Scheme of Food Safety Supply Chain Traceability Management System

5. Conclusion

The food security problem is a serious problem for the people of our country. With the frequent occurrence of Chinese food security issues, how can we eat the safety food is an important issue. In order to ensure the food security monitoring and tracking system, and achieve the whole monitoring system which is from the field to the table, it is necessary and urgent to establish the food traceability system.

In this paper, we applied the RFID technology to the food security supply chain traceability management system based on the Internet of things. Based on determining the traceability of each link in the food supply chain, using the RFID electronic label for the data carrier can identify the food, achieve the automatic acquisition of the data and enhance the precision and accuracy of the individual marking. The establishment of the system not only could achieve the supervision of the food which is from the farm to the

table, but also define the responsibility of each enterprise in the supply chain. Once the security problem occurs, the traceability can find out directly the related enterprises. At the same time, it achieves the effective traceability and tracking for the food quality security in the food supply chain.

Acknowledgements

References

[1]   M. M. Aung and Y. S. Chang, "Traceability in a food supply chain: Safety and quality perspectives", Food Control, vol. 39, **(2014)**, pp. 172-184.

[2]   D. Pinto, I. Castro and A. Vicente, "The use of TIC's as a managing tool for traceability in the food industry", Food Research International, vol. 39, no. 7, **(2006)**, pp. 772-781.

[3]   A. Regattieri, M. Gamberi and R. Manzini, "Traceability of food products: general framework and experimental evidence", Journal of Food Engineering, vol. 81, no. 2, **(2007)**, pp. 347-356, 464.

[4]   C. Robson, Y. Watanabe and M. Numao, "Parts traceability for manufacturers", In IEEE 23rd international conference on data engineering, Istanbul, Turkey, **(2007)**, pp. 1212-1221.

[5]   M. Zhang and P. Li, "RFID Application Strategy in Agri-Food Supply Chain Based on Safety and Benefit Analysis", P hysics Procedia, vol. 25, **(2012)**, pp. 636 – 642.

[6]   S. Pin, "Researrch on Agi-products safety traceability system based on Multi-Agent", Science & Technology Information, vol. 6, **(2012)**, pp. 24-26.

[7]   K. Dawei, "Research on the construction of food traceability system based on supply chain management", Chengdu Univerisity of Technology, business administration, **(2013)**.

[8]   F. Yali, "Analyses of pork traceability system regulated by government", Sichuan Agricultural University, management of agricultural economy, **(2012)**.

[9]   Z. Li, X. Bin, L. Wenyong, W. Xiaoming and Y. Xinyan, "Agricultural Products Quality and Safety Traceability System Based on Two-dimension Barcode Recognition of Mobile Phones", Transactions of the Chinese Society for Agricultural Machinery, vol. 43, no. 7, **(2012)**, pp. 124-129.

[10] W. Wei, "Ria based quality and safety traceability system for chicken industry", Zhejiang University，Agricultural Electrification and Automation, **(2013)**.

[11] H. Hailong, "Research and development on quality and safety traceability system of agricultural producers based on NET technology", Xinjiang Agricultural University, soil information system, **(2010)**.

[12] C. Fang and Z. Qijun, "Study on Food Traceability System Based on Information Asymmetry", Heilongjiang Agricultural Sciences, vol. 9, **(2011)**, pp. 112-115.

[13] L. Pingzheng, J. Zhen, L. Jiali, L. Hua and M. Kai, "A whole course food tracing system based on three dimensional code", Journal of Shenzhen University Science and Engineering, vol. 27, no. 3, **(2007)**, pp. 312-316.

[14] Y. Tao, "Research on constructing retrospecting system of agricultural product supply chain", Southwest Jiaotong University, logistics engineering, **(2007)**.

Author

Kefei Liu, 13/Mar./1975, Zhengzhou, Henan
Current position, grades: Associate professor
University studies: Agricultural economics
Scientific interest: Food safety supply chain
Publications: Liu KeFei.The Industry Chain-Based Food Quality and Safety Management System Construction. Biotechnology: An Indian Journal, 10, 4127-4133(2014).
Experience: Sept., 1993 - Jun., 1997, Bachelors of Trade and Economic, Henan University of Finance and Economics, China
Jul., 1997 - present, Associate professor, Henan University of technology, China
Sept., 2002 - May, 2005, Master of Business Administration, Xi`an Jiao tong University, China