CONSTRUCTION OF TRACEABILITY SYSTEM FOR MAINTENANCE OF QUALITY AND SAFETY OF BEEF

Wanli Zhang, Xiaoying Yang and Qixiang Song

College of Information Engineering, Suzhou University, Suzhou, China

Email:zhangwanli0557@aliyun.com

Submitted: Oct. 2, 2014 ***Accepted: Jan. 24, 2015*** ***Published: Mar. 1, 2015***

Abstract-In order to allow consumers to trace to the whole process of beef breeding, production and processing after purchasing beef, to achieve smart, fast and practical goals for quality and safety of beef traceability system, B / S (Browser / Server) mode architecture is used to build quality beef traceability system based on RFID technology in this paper. First, the system is analyzed, the structure and database system are designed and the key technologies to achieve traceability system is explored, including the individual identification of cattle, data encoding, data synchronization technology between the business and the central database and multi-platform tracing techniques. Through the use of RFID technology, all aspects of information for each head of beef cattle from breeding, slaughtering, processing, cold chain storage and transportation can be tracked and traced, and a quality retrospective file which can be queried on the Internet network for each head of beef cattle is formed. Solve the problem which the origin of beef production can be quality controlled and is traceability. The system implements safety warning function for cattle breeding epidemic and product quality, so it can ensure the safety of beef products from all aspects of production management. Finally, the renderings of system implementation are gained.

Index terms: RFID technology, beef quality, traceability system, ear tag, product safety.

I. INTRODUCTION

With economic globalization, cross-border and inter-regional flow of food more frequently, a variety of food safety incidents and hazards were rapidly expanding and is spreading [1]. How to ensure the safety of meat had been global issues which placed in front of today's government, food manufacturers and food scientists and urgent to be solved [2]. To this end, scholars at home and abroad conduct a lot of research on building safety system framework of the whole process of beef production [3].

In other countries, radio frequency identification (RFID) technology in the field of food quality control has been widely studied [4,5,6]. Australia established a livestock labeling and traceability system, using a unified electronic identification ear tags for cattle management [7]. Japan has established a food card system since 2001, namely agricultural biographical system which is used to implement agricultural production and marketing tracking [8]. SYSCO company, North America's largest food service marketing and distribution organization has showed that the ability of RFID in monitoring temperature, humidity and other environmental parameters during transport is strong, can effectively ensure food quality and quality safety. In domestic food security, RFID technology has gradually become a hot research [9,10]. At present, the domestic traceability system mostly establish for farms or processing enterprises, often neglected phase of product sales tracking and tracing [11,12,13,14]. The product sales stage is the entrance to fake and shoddy products into the consumer market. If you neglect this stage of the product information monitoring, resulting in counterfeit products into the consumer market, so tracing for farms and processing enterprises upstream would be meaningless. Therefore, in-depth study of beef cattle traceability system to track the product life cycle, to improve the quality and safety of beef in China, increasing consumer confidence in beef consumption has far-reaching social significance.

In this study, the RFID technology is introduced to identify individual and beef cattle, and the collected data of the growth of cattle, beef processing and marketing of various processes is uploaded to network database which is designed in "PHP + MySQL", the whole process of product quality beef tracking and tracing can be achieved.

II. SYSTEMS ANALYSIS

Beef production process is a complete supply chain [15], according to the current situation of China's aquaculture industry, and its information tracing mechanism can be summarized as three key nodes:

1) Farms, slaughtering farm, production and processing enterprises, other supply chain members, government agencies, as well as the third-party organizations and trade market provide the basic data for the traceability system through food safety supervision, software and hardware platform.

2) Center database of traceability of beef quality and safety information and monitoring and early warning system supervise and analyze received information to provide authoritative information to consumers and provide product information and services for businesses and suppliers.

3) Consumers can found product information and business related authentication information and feedback through the Internet, kiosk terminals sales outlets. At the same time, regulators and members of beef production and processing supply chain do some appropriate process based on feedback.

Shown in Figure 1, beef production and processing of information traceability process are distributed on each link in the supply chain nodes.

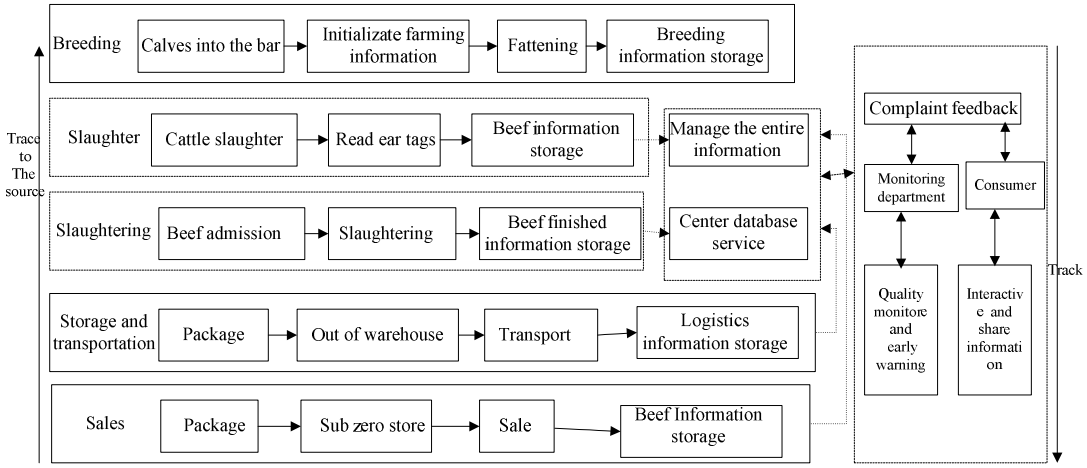

Figure 1. Quality beef traceability system architecture and data flow

Beef production, cattle slaughtering and processing enterprises first applied for certification of production of "pollution-free, green" beef cattle product identification to a third-party beef

cattle management system (reporting information including the location, the full name of the applicant, product names, trademarks, annual and other information). Third-party system management department organize personnel to test, publish beef production company directory on the website after testing, and promotion of its products and distribution purchase, sale information.

Beef producers take cattle barns as the unit to record each barns cattle breeding information. After 1.5 to 2 years, the production of beef products is tested and inspected by inspection and quarantine departments, it will be sent to slaughter and processing sectors after passing inspection.

Slaughter and processor record for each batch of beef slaughter and processing information. The products of production beef enter the areas of circulation and sale after inspection and quarantine. People of storage and transportation record reception, storage, warehousing and cargo send a message of transportation links.

Sellers record sales cycle information. Consumers can inquiries all aspects of the sales information from cattle rearing, beef slaughter and processing, storage and transportation to sale through network, SMS, telephone and other media after buying beef products. Founding that product quality problem, they can complain through product traceability codes.

System management department view and audit management, epidemic early warning and beef product quality and safety warnings of information reported by cattle producers and slaughter and processors. Specific implementation is shown in Figure 2.

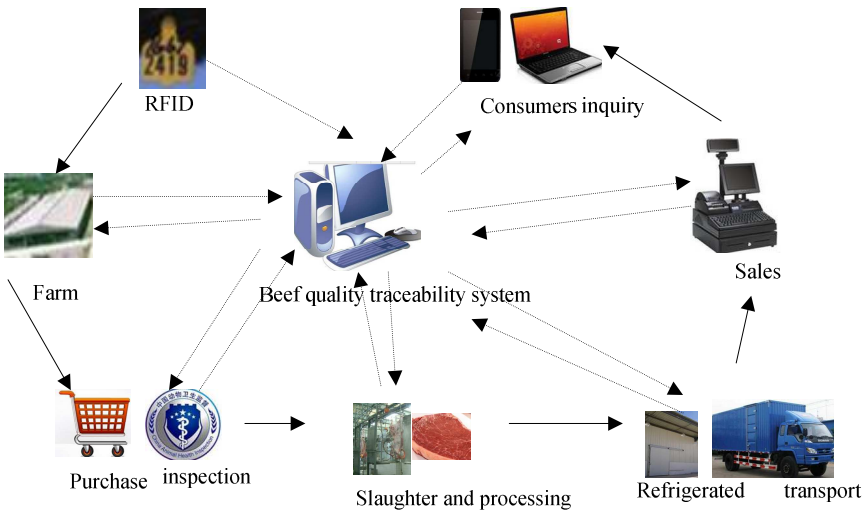

Figure 2. Specific implementation

III. SYSTEM DESIGN

a. System Components

Safety of beef traceability system (referred to as "beef traceability system") focused production of from factory farms to large slaughterhouses, to supermarket sales. According to beef production process, "beef traceability system" includes aquaculture production, slaughtering, processing and supermarket sales three application modules, each module including growth monitoring and growth information tracking.

1) Beef farm system mainly records and manages archives of the growth process of beef; buy, store, collect and use veterinary medicine, feed and disinfection products, and whether breeding environment meets the standards and law of national or regional; early warning of irregularities.

2) The Slaughter system mainly monitors beef transport; converts beef individual identification information; preserves and records archival of cattle; beef monitoring test results; beef storage and transportation monitoring; early warning of irregularities.

3) Sales system mainly monitors beef environmental safety, health and price, the health of the sales staff and sales aspects of beef stored in compliance with relevant regulations and standards, while providing consumers with information queries.

b. Traceability system architecture design

The system software is designed on the basis of previous studies on the use of PHP + SQL 2005 to develop and design. Dynamic web is designed by using PHP, the collected cattle rearing and slaughter and processing, and other related information are stored in the network database. Access and share information by using Web dynamic interactive technology and browser / server (B / S) mode to, so all levels producer and consumer can inquiry and trace.

The system consists of a core of enterprise management systems, central database, consumer-oriented retrospective platform. Core system consists of three parts which are client layer, application layer and database layer, shown in figure 3. Client layer uses PHP to design client dynamic page, mainly to complete the interaction between user's front functions and back functions and output final results query; Application layer, which is the core of the

system, depending on the different data request realizes the data processing and computing and completes the application logic and functionality of quality traceability system users by returning the need data format through data conversion middleware; Database layer, including all data related to the platform, which include user information, product information, process information, historical information and so on, achieves traceability data information storage and management and provides data support to quality traceability system function. It exchanges data with other enterprise systems on supply through the Web Service, provides to consumers in the form of services and consumers query in network by product number after purchasing products.

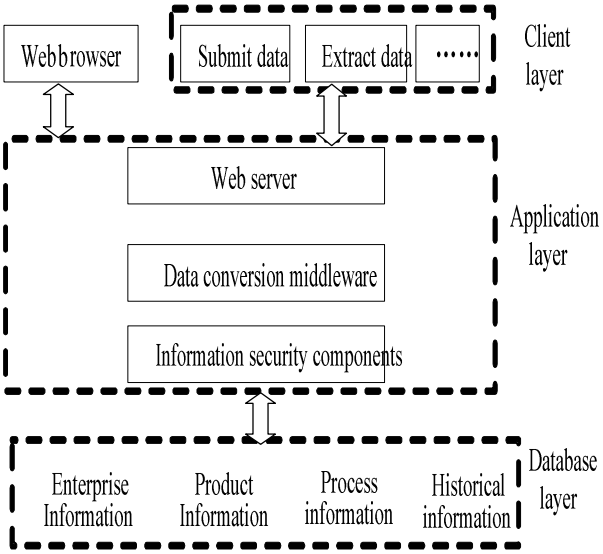

Figure 3. Core system architecture

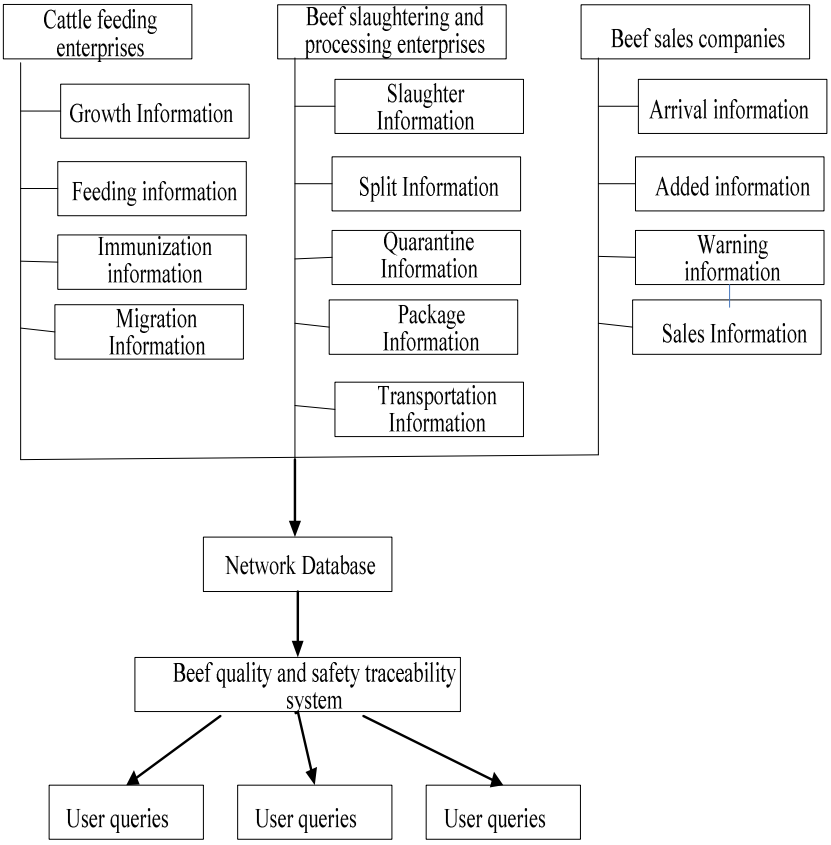

Figure 4. The overall design of the structure diagram of the system

The overall design of the structure diagram of the system is shown in Figure4, the foreground structure of the system is shown in figure 5 and background function structure of the system is shown in Figure 6.

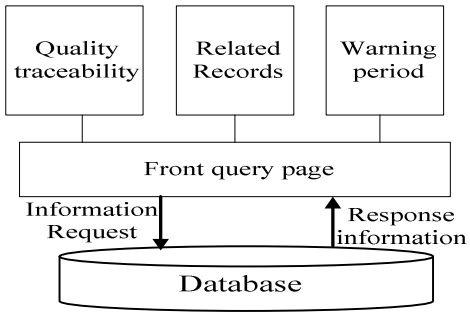

Figure 5. The foreground structure of the system

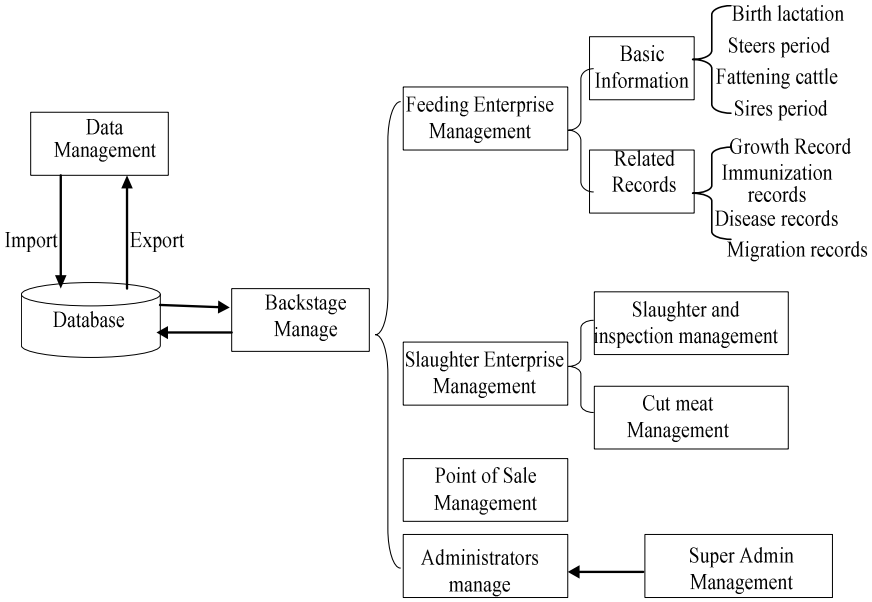

Figure 6. The background function structure of the system

c. Database design

Some of the database tables which are designed in the system are shown as follow.

Table 1: RFID ear tag table

Field name	Data Types	Constraint
earid(Ear label)	Varchar(30)	Primary Key
weight(Slaughter weight)	Varchar(30)	NULL
munityrecs(Immu-nization records)	Varchar(30)	NULL
treathrecs(Treatme-nt records)	Varchar(30)	NULL
Birthday(Date of birth)	Varchar(30)	NULL
Feeders(Feed)	Varchar(30)	NULL
health(Health Status)	Varchar(30)	NULL

Table 2: feed fed table

Field name	Data Types	Constraint
feedid (Feeding No.)	int	Primary Key, Denity(1,1)

earid(Ear label)	Varchar(30)	Primary Key
feedstiffid(Feed No.)	Varchar(30)	NULL
feedingday(Fee-ding time)	Varchar(30)	NULL
feedstatus(Fed -state)	Varchar(30)	NULL
operator(Breeder)	Varchar(30)	NULL

Table 3: Beef treatment table

Field name	Data Types	Constraint
earid(Ear label)	Varchar(30)	Primary Key
treathid(Treatment No.)	int	Primary Key, Denity(1,1)
cattleid(Kraal No.)	Varchar(30)	NULL
dieeasename(Cattl-e Disease Name)	Varchar(30)	NULL
dieeaseday(Treat-ment Date)	Varchar(30)	NULL
treathmethod(Trea-tment methods)	Varchar(30)	NULL
treater(Veterinary)	Varchar(30)	Varchar(30)

Table 4: Slaughter Table

Field name	Data Types	Constraint
earid	Varchar(30)	Primary Key
slaughterid	int	Primary Key, Denity(1,1)
Slaughter people	Varchar(30)	NULL
Slaughteday	Varchar(30)	NULL
Slaughter voltage	Varchar(30)	NULL

IV. THE KEY TECHNOLOGIES OF TRACEABILITY SYSTEM

a. Identification of individual cattle

Identification of individual cattle and safety tracking and traceability of identification of food require strict surveillance from the production source, it also requires each cow code should have a unique identification code marked and convenient entry and read. RFID(Radio Frequency Identification) technology is a non-contact automatic identification technology[16], automatically distinguishes target objects and gets relevant data, can work in a variety of harsh environments; may identify fast moving objects; may also identify multiple tags; quick and easy be operated. So the "RFID + bar code" technology is used to achieve full control and traceability of beef products.

Each calf from birth, the breeder will use a fixed reader unified to write the ear tag of the cattle based on the initial information of each cattle. Written information include unique RFID ear tag of cattle which automatically generated by the system default, the origin of the beef, immune information, treatment records information and other important information of beef individual. The ear tag and file will follow the cattle migration and metastasis. Each time when the performance of growth of cattle or migration is measured, both the information on the ear tag will be red by using the reader and promptly uploaded to the web server.

In daily feeding process, when the breeder operates a cattle once, he can use handset to read the ear tag in order to record all specific operations carried out against the cow and write important information of directly related to beef quality and safety such as immunization, treatment etc.. After completion of the operation every day, via serial communication between handset and computer, the system will automatically store breeding record of every beef cattle in the system database, keeping a log form in the database. When cattle leaves the pen, system forms breeding traceability information of each head of beef cattle by keeping a log of these finishing.

When cattle enter into the slaughterhouse, the ear tag need to be scanned and will be transferred to the RFID tags on the hook. Beef is segmented after arranging acid and maturing, then reads the RFID tag information hanging on hooks on the beef, then print out the

corresponding one-dimensional bar code, post on the division of the meat packing and it will be sold.

When carcass leave slaughter line, the system reads the electronic identification number, to obtain the corresponding ear tag through the database, using a one-dimensional bar code to finally identify carcass or meat division until sold in supermarkets, thus ensuring that users buy each piece of meat have the original code carcass.

b. Data coding

Ear tag coding design of cattle uses 14 digits. The first 8 digits represent detailed birthplace of cattle, where four represents provinces code, and the remaining four is different farming organization code; The last 6 represents the actual sequence number of the cattle breeding organization, which two digits represents birth reign, and the remaining four is the actual sequence number of that year for cattle, so that the ear tag contains the ears of cattle bovine origin, year of birth, and other basic information. As shown in figure 7.

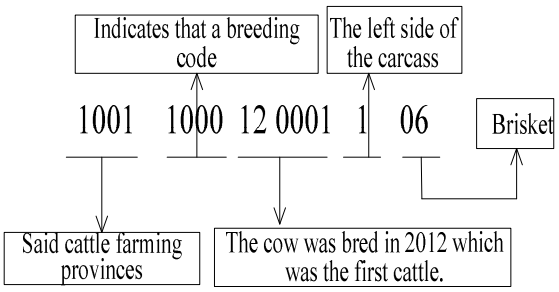

Figure 7. Ear tag numbers of cattle

c. Data synchronization technology

Data synchronization means in a network environment, data of each beef production and processing companies maintain consistency with updates for the central database of cattle - cattle processed safety traceability system, so that you can ensure the timeliness of the convergence of information and traceability of the supply chain before data . The system uses XML (eXtensible Markup Language) to Extensible Markup Language data synchronization [17]. Operator business side by selecting a date, the system updates data automatically separated and converted to XML, data synchronization module starts, dating back end system to automatically determine whether this data exist in the center, if there is, data synchronization exit, if not, then XML data is desterilized as data recorded and added to the

retrospective central database. Such updates manner is suit both for beef production enterprise without a good network environment, but also can reduce the amount of time to update the data, which is shown in Figure 8.

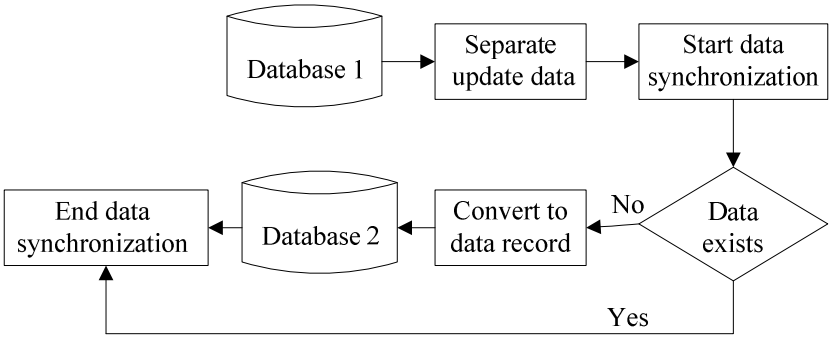

Figure 8. Data Synchronization

d. Multi-platform retrospective technology

The system provides a variety of ways such as SMS, website, telephone and terminal scanning to achieve product traceability, although the platform is different, but the data is synchronized between the platforms, so consumers no matter by what traceability platform, can trace the latest product information [18]. Specific procedures for traceability: consumers enter the product code through various platforms, traceability system based on a lookup table to determine whether retroactive had been traced. If you have already traced, the system would have been retroactive time, IP address, or phone number is returned to the consumer; if not, the traceability system will return the relevant traceability information to consumers. This makes it conducive to the realization of the security products. Multi-platform retrospective flow is shown in Figure 9[19].

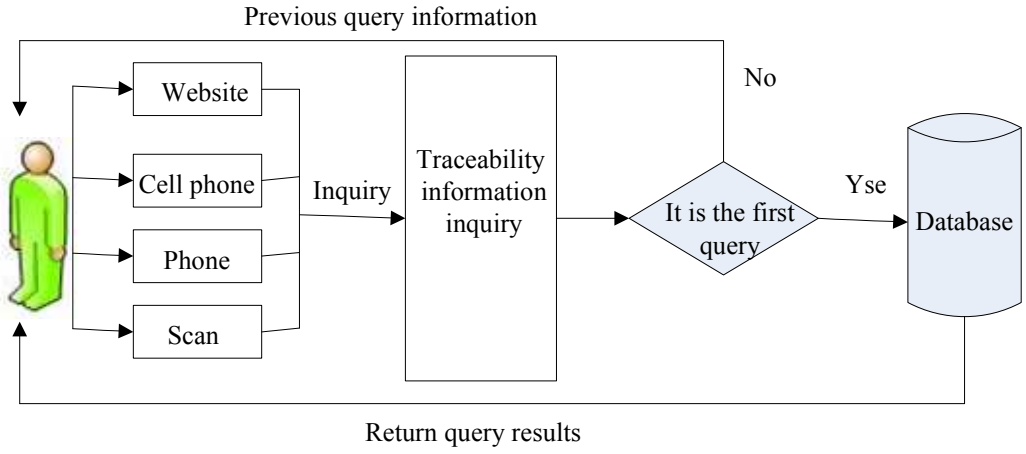

Figure 9. Multi-platform information query

V. SYSTEM IMPLEMENTATION

The system uses the MVC (Model View Controller) design pattern [20]. The system consists of three parts: Model refers to the business data / information processing modules [21], including access processing, computing and integration of business data, namely the database module, which is a key part of the program to be executed and is responsible for establishing the connection to the database, creating a data table, storing data and in response to user queries, etc. in the system. View refers to the user interface which is user-oriented data show, namely the front display module which provides tracking of each piece of beef traceability information to consumers and the result is to be displayed by the view after the operation of the database module. Controller is used to manage interaction which occurs between user and the view to determine appropriate keyword of the query information, and is responsible for handling Model, manage it in order to satisfy the query of the user interface.

The ordinary user does not need to log in to query the related information, the administrator log in which requires a user name and password. Main interface of the system is shown in Figure 10. Administrators can query, add, modify, and delete the relevant information, farm administrator to add information page shown in Figure 11.

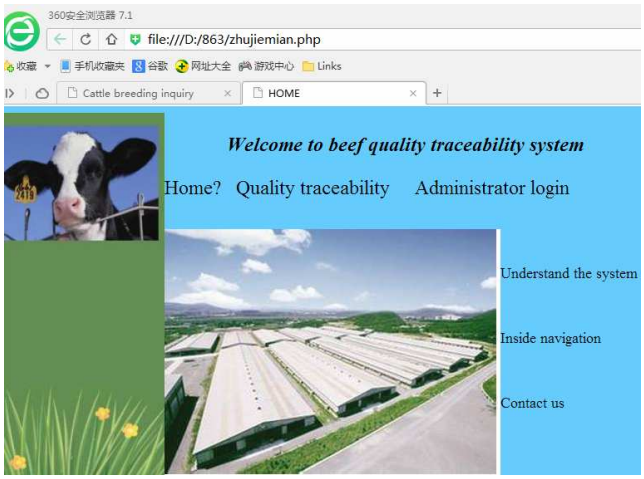

Figure 10. Main interface

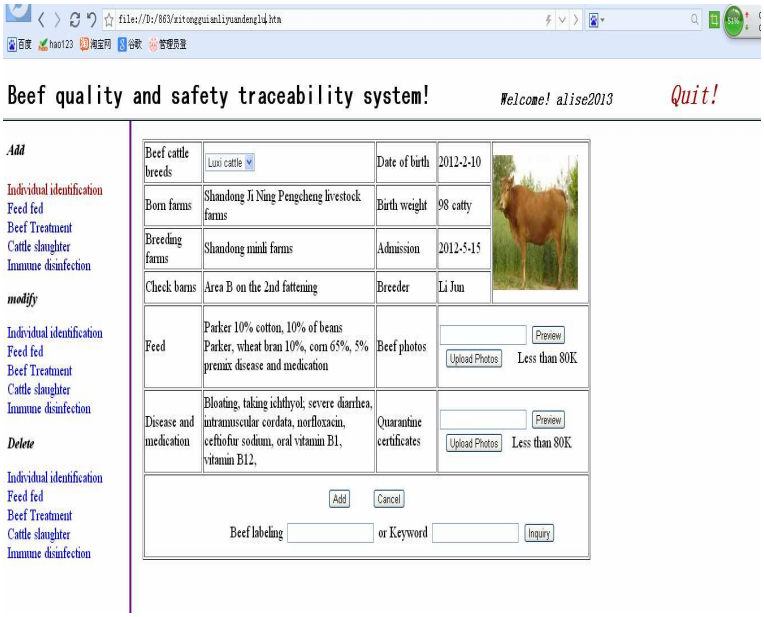

Figure 11. Farm administrator add information

Ordinary users can query cattle breeding, slaughter, storage and sales information and so on of beef. Part of the query pages are shown in Figure 12 to Figure 16.

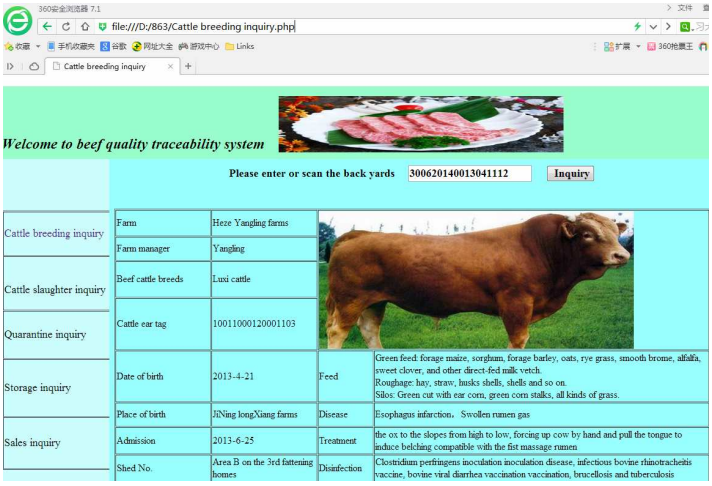

Figure 12. Cattle breeding inquiry

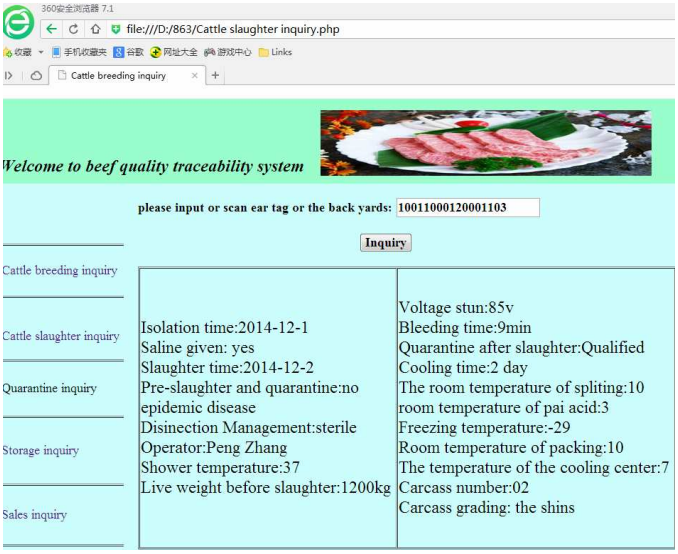

Figure 13. Slaughter inquiry

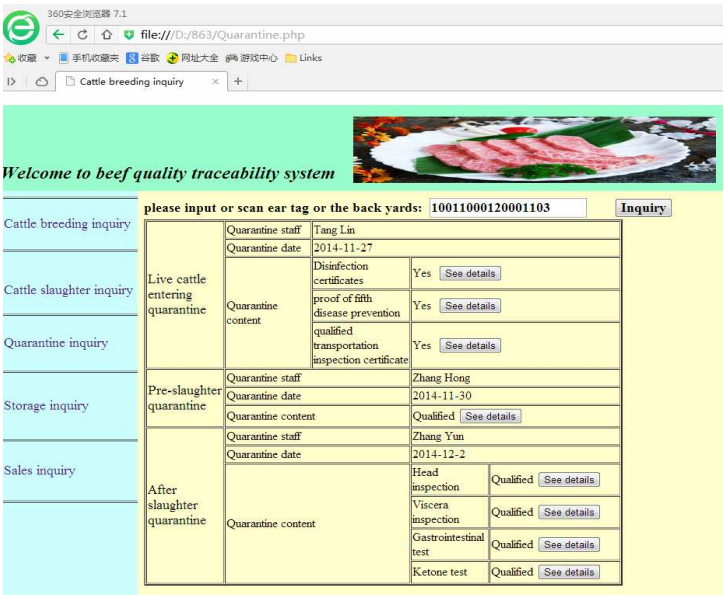

Figure 14. Cattle quarantine inquiry

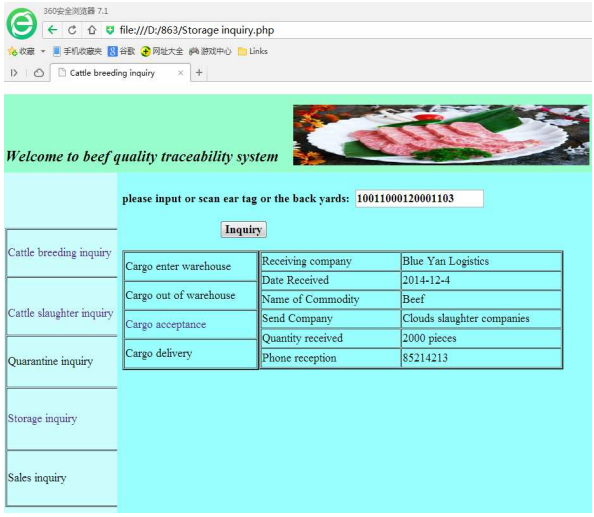

Figure 15. Storage inquiry

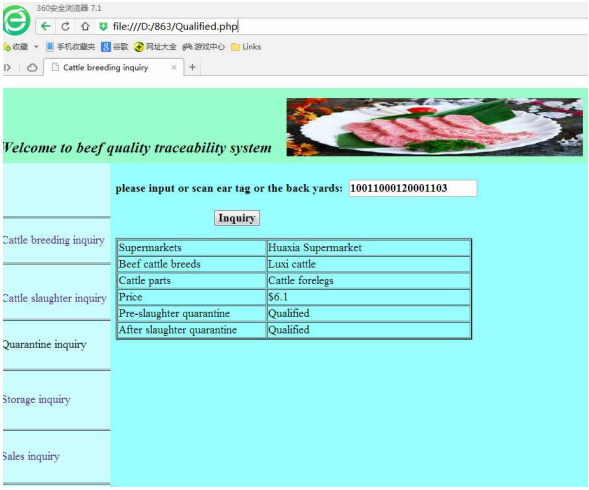

Figure 16. Sales inquiries

VI. CONCLUSIONS

Quality and safety of beef traceability system based on RFID technology takes into account the interests of producers, regulators and consumers in three aspects. Because this system effectively monitor the farming environment, it not only improves the quality of beef cattle which are raised, reduces business risk of farming enterprises due to high rate of Cattle culling rate, but also forms a reliable and accurate traceability of product quality information for every head of cattle. Regulators can timely guide on beef cattle production and quality safety of beef products is implemented certification, inspection, market access, early warning and confirmation of responsibility in order to achieve effective supervision. Consumers

inquiry a variety of information from production to sales information of the purchased beef products through a variety of inquiries media, evaluate and complaint to protect their interests.

Traceability system covers cattle breeding, slaughter and processing and other industry standard system and regulates the behavior of producers of beef cattle industry chain and promotes the standardization of production. It Realizes function that from beef production, slaughter and processing, cold chain storage and transportation to all aspects of the sales information can be traced and has the function of early warning for beef epidemic and beef product quality and safety. The system can make the alarm before quality and safety of beef products event occur or occur early. When the quality of security incidents occurs, it can implement in specific units of specific responsibilities, such as specific links and forms of in what time, in what circumstances, with which form to produce beef and slaughter and processing by who in what time, in what way to inspect and quarantine, and by what transport sector transport, have been where you are, enters which warehouses, the warehouse is responsible by who, how is warehouse storage environment, specific information sellers, all of these can be reflected. After the promotion and application of beef production process tracking and safety traceability platform, beef products safety is ensured and improves public confidence in beef product traceability from the various aspects of production management.

ACKNOWLEDGEMENT

This work was supported by Young Talents Fund Project in Anhui Province of China (No.2013SQRL083ZD), Anhui University Provincial Natural Science Research Project (No.KJ2014A247) and Open platform topics of Suzhou University of China (No. 2012YKF38), University student's Innovative Training Project(201310379019).

REFERENCES

[1] Esun Karabudak, Murat Bas, Gul Kiziltan, “Food safety in the home consumption of meat in Turkey”, Food Control, Vol.19, 2008, pp. 320-327.

[2] Jevsenik M, Hlebec V, Raspor P, “Consumers’ awareness of food safety from shopping to eating”, Food Control, Vol.19, no.8, 2008, pp. 737-745.
[3] Julio Garrido Campos,Martin Hardwick, “A traceability information model for CNC manufacturing”, Computer Aided Design, Vol.38,no.50,2006, pp. 540-551.
[4] Mohd Syaifudin Abdul Rahman, S. C. Mukhopadhyay, and Pak-Lam Yu, Novel Sensors for Food Inspection: Modelling, Fabrication and Experimentation, 978-3-319-04273-2, Smart Sensors, Meas. and Instrumentation, Vol 10, Springer-Verlag, 2014.
[5] Loureiro M L, Umberger W J, “A choice experiment model for beef: What US consumer response tell us about relative preference for food safety, country of origin labeling and traceability”, Food policy, Vol.32, 2007, pp. 496-514.
[6] Asif I. Zia, Mohd Syaifudin Abdul Rahman, S. C. Mukhopadhyay, Pak-Lam Yu, I.H. Al-Bahadly, Chinthaka P. Gooneratne, Jürgen Kosel, Tai-Shan Liao, Technique for rapid detection of phthalates in water and beverages, Journal of Food Engineering 116 (2013) 515–523.
[7] Mauro Conter, Emanuela Zanardi, Sergio Ghidini, et al, “Consumers’ behaviour toward typical Italian dry sausages”, Food Control, Vol.19, no.6, 2008, pp. 609-615.
[8] Rahman, M.S.A., Mukhopadhyay, S.C., Yu, P.L., Goicoechea, J., Matias, I.R., Gooneratne, C.P., Kosel, J., Detection of Bacterial Endotoxin in Food: New Planar Interdigital Sensors based Approach, Journal of Food Engineering, 114 (2013) 346 – 360, 2013.
[9] McMeekin T A, Baranyi J, “Information systems in food safety management”, International Journal of Food Microbiology, Vol.112, 2006, pp. 181-194.
[10] Mohd Syaifudin Abdul Rahman, S. C. Mukhopadhyay, P.L.Yu, C.H.Chuang and M. Haji-Sheikh, “Measurements and Performance Evaluation of Novel Interdigital Sensors for Different Chemicals Related to Food Poisoning”, IEEE Sensors Journal, Vol. 11, No. 11, November 2011, pp. 2957-2965.
[11] Dupuy C, Botta-Genoulaz V, Guinet A, “Batch dispersion model to optimize traceability in food industry”, Journal of Food Engineering, Vol.70, no.3, 2005, pp. 333-339.
[12] Orru, Napolitano F,Catillo G, Moioli B, “Meat molecular traceability: How to choose the best set of micro-satellites”, Meat Science,Vol.72,no.2,2006,pp. 312-317.
[13] Regattoeri A,Gamberi M, Manzini R, “Traceability of food products: General framework and experimental evidence”,Journal of Food Engineering,Vol.81,no.2,2007,pp. 347-356.
[14] Ren Shougang, Xu Huangliang,Li An, “Meat-productions tracking and traceability system based on internet of things with RFID and GIS”, Transaction of the CSAE. Vol.26, no.10, 2010, pp. 229-235.
[15] Shi Liang,Fu Zhetian,Zhang Lingxian, “Safety On RFID-based traceable system for quality insurance of beef cattle breeding”, Computer Applications and Software, Vol.27,no.1,2010,pp. 40-43.
[16] Qian Jianping, Yang Xinting,Zhang Baoyan, Wu Xiaoming, Xue Pin, “RFID-based

solution for improving vegetable producing area traceability precision its application", Transaction of the CSAE, Vol. 28,no.15,2012,pp. 234-239.

[17] Luo Qingyao, Xiong Benhai, Yang Liang, "Solution of data collection of swine slaughter based on ultrahigh frequency RFID", Transactions of the CSAE, Vol. 27,no.2,2011,pp. 370-375.

[18] PettittR G, "Traceability in the food animal industry andsupermar-ketchains", Rev Sci Tech of Int Epiz, Vol.20, no.2, 2001, pp. 584-597.

[19] Stanford K, Stitt J, Kellar J A, "Traceability in cattle andsmallruminants in Canada" ,Rev Sci Tech of Int Epiz, Vol. 20,no.2,2001,pp. 510-522.

[20] Wang Tingman, Zhang Xiaoshan,Chen Wei, Fu Zhetian, Peng Zhaohui, "RFID-based temperature monitoring system of frozen and chilled tilapia in cold chain", Transaction of the CSAE, Vol.27,no.9,2011,pp. 141-145.

[21] Zhang Ke,Cai Yi,Wong Daolei, "Analysis and design of information traceability system of pork production supply chain", Transaction of the CSAE, Vol.26,no.4,2010,pp.332-339.

[22] Xiong Benhai, Fu Runting, Lin Zhaohui, "A solution on pork quality safety production traceability from farm to dining table: taking tianjin city as an example", Scientia Agricultura Sinica, Vol.42, no.1, 2009, pp. 230-237.

[23] M. Krotkiewski and M. Dabrowski, "Parallel symmetric sparse matrix-vector product on scalar multi-core CPUs", Parallel Comput, Vol. 36, no.4, 2010, pp. 181-198.

[24] Liu Peng, Tu Kang, Hou Yuepeng. "Traceability system of grain quality safety based on RFID middleware ,"Transaction of the CSAE,Vol.25,no.12, 2009,pp.145-150.

[25] A. R. Mohd Syaifudin, S. C. Mukhopadhyay and P. L. Yu, Modelling and fabrication of optimum structure of novel interdigital sensors for food inspection, International Journal of Numerical Modelling: Electronic Networks, Devices and Fields, Volume 25, Issue 1, January/February 2012, Pages: 64–81, Article first published online : 25 APR 2011, DOI: 10.1002/jnm.813

[26] Hobbs J E, "Traceability in the agri-food sector: Issues, insight and implications", CAB reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources, Vol.1, no.029, 2006, pp. 1-7.