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CONSTRUCTION AND IMPLEMENTATION OF QUALITY SAFETY TRACEABILITY SYSTEM OF FRESH AGRICULTURAL PRODUCTS— TAKING BEEF SUPPLY AS AN EXAMPLE

Yongbo Lai*[1, 2], Xuerong Xu[2]

[1]*College of Public Affairs, Fujian Jiangxia University, Fuzhou, 350108, Fujian, China;*
[2]*College of Economics, Fujian Agriculture and Forestry University, Fuzhou, 350002, Fujian, China;*
xuxuerongxx@163.com

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ABSTRACT
In this study, taking beef supply as an example, we applied information technology to the construction and implementation of a quality safety (QS) traceability system of fresh agricultural products, under the guidance of the related experience in guaranteeing QS of agricultural products. In view of the relevant practical experience, we revealed the existing problems of the QS traceability system for fresh agricultural products. Then, we proposed the modeling method of Petri net, followed by establishment of traceability model of feeding process based on Petri net; moreover, we completed the modeling of traceability system. In addition, we established the database and traceability platform for quality safety information of beef supply; using information technology and database technology, we completed the construction and implementation of the quality safety traceability system of fresh agricultural products.

1.Introduction

Recently, the occurrence of food quality safety incidents, such as the outbreak of mad cow disease and application of melamine, has caused people's fear on food quality safety. Under the circumstance, consumers request more severe regulation of food quality safety (Amadou, 2014). With extensive attention from government departments and the public, the problems have promoted the researches of traceability systems for food quality safety (Zhen-Huan et al., 2011; Wu et al., 2013; Bazant et al., 2014). Food safety issues not only bring damage to consumers' health and social economy, but also restrict the sustainable development of food industry; consequently, economic development and social stability are affected (Jarvis et al., 2016). In China, agricultural exports account for a large proportion of the export products. However, in recent years, the agricultural products exported from China have been repeatedly investigated, detained and prohibited because of quality safety problems, which has affected the international competitiveness of Chinese agricultural products (Chen et al., 2011). Therefore, the current research emphasis is laid on developing high-yield and high-quality agriculture as well as establishing an agricultural product traceability and regulation system (Zanella and Milhorance, 2016; Mahmood et al., 2015). In terms of livestock and poultry products, pilot sites for traceability application of beef products were established in Beijing; in Shanxi province, the whole-course tracking system for beef supply was established; in Shenzhen city, the quality traceability system for the production process of beef products was established. The whole traceability system includes three basic elements: individual mobile registration, information transmission system as well as the individual identification and database of agricultural products. Therefore, it is of important practical significance to establish a traceability system which covers the key links (production, processing, transportation, storage and marketing) of agricultural products, to ensure their quality safety.

In this study, we established a quality safety traceability system which could be applied to the whole-process tracking and supervision of production, processing, storage, transport and marketing of fresh agricultural products. The system was conducive to promoting the information transparency of each key link in the supply chain (Villeneuve, 2014), improving the quality assurance of agricultural products, increasing market competitiveness and achieving traceability of quality safety; furthermore, it could further promote the development of agricultural industrialization.

2. Analysis and construction of traceability system

2.1. Analysis on the performance requirements of traceability system

The performance requirements of quality safety traceability system for fresh agricultural products included: instantaneity and accuracy of data acquisition, reliability of data transmission, consistency of data storage, friendly interface, qualified operation time, reliability of safety performance. At each stage of system development, the authentication and authorization needed to be considered. The system was mainly targeted at consumers, managers and key point enterprise users. Therefore, it was necessary to authorize different users appropriately, so that they were able to use specific functions of the system to complete different tasks (Pang et al., 2016).

2.2. Establishment of traceability system model

2.2.1. Feeding model based on Petri net

Traceability covered two aspects: firstly, when purchasing fresh food, consumers could use barcode technology to inquire and browse the historical information related to the supply links of fresh products; secondly, when quality safety issues of fresh agricultural products occurred, the relevant departments could use bar code labels to trace down the problems. The model is shown in Figure 1.

Production was a key link in guaranteeing the value and quality of fresh agricultural products (Holgersson et al., 2016). In this paper, beef cattle breeding was taken as an example and traced. In the production process, each fresh agricultural product was assigned with a barcode label to certify its identity and record its basic information and key information such as feeding and drug use in the production process. Petri net model of the raising process (from introducing to fattening) of qualified feeder cattle is shown in Figure 2.

Through the analysis on the transition of feeder cattle fattening model, the transition mapping table was obtained, as shown in Table 1.

2.2.2. Traceability information model of the storage and transportation link

In the storage and transportation link, the data information that needed to be collected mainly included: the basic information of the staff responsible for QS of the fresh agricultural products, transport equipment and route, QS information of the products during transport. The flow diagram is shown in Figure 3.

2.2.3. Traceability information model of marketing link

Taking the consumption of fresh agricultural products as an example, the application of barcode in the marketing link was illustrated. The flow diagram is shown in Figure 4.

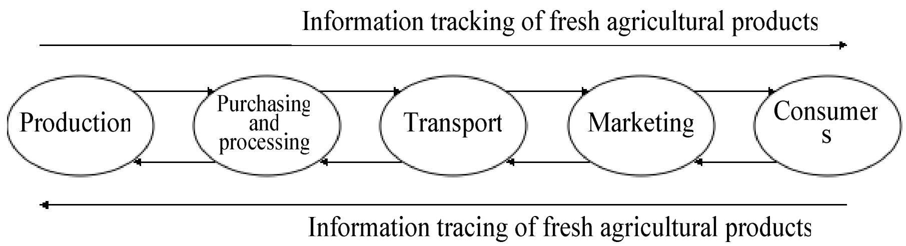

Figure 1. Model of information tracking and tracing of fresh agricultural products

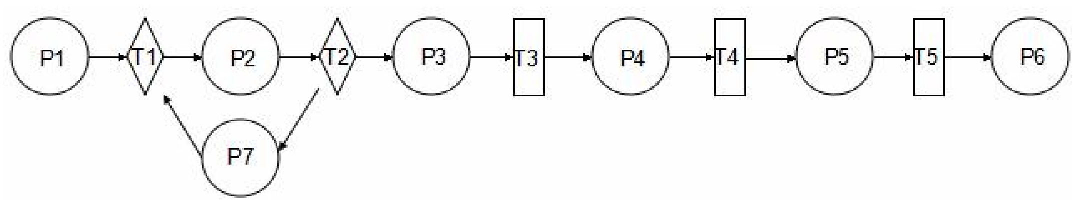

Figure 2. Petri net model of the raising process of feeder cattle

Table 1. Petri net transition mapping table of feeder cattle

Transition	Meaning	Place	Meaning	Role
T1	Managers introduced feeder cattle	P1	Feeder cattle to be introduced	Managers
T2	The feeder cattle were quarantined	P2	Feeder cattle introduced from pasture	Quarantine officers
T3	After examination and approval, the cattle were switched to another group	P3	Qualified feeder cattle	Quarantine officers
T4	The feeder cattle were fed	P4	The cattle to be fattened (in the new group)	Feeders
T5	Managers registered the cattle for marketing	P5	Fattened cattle	Feeders
--	--	P6	The total fattened cattle	Managers
--	--	P7	Unqualified feeder cattle	Quarantine officers

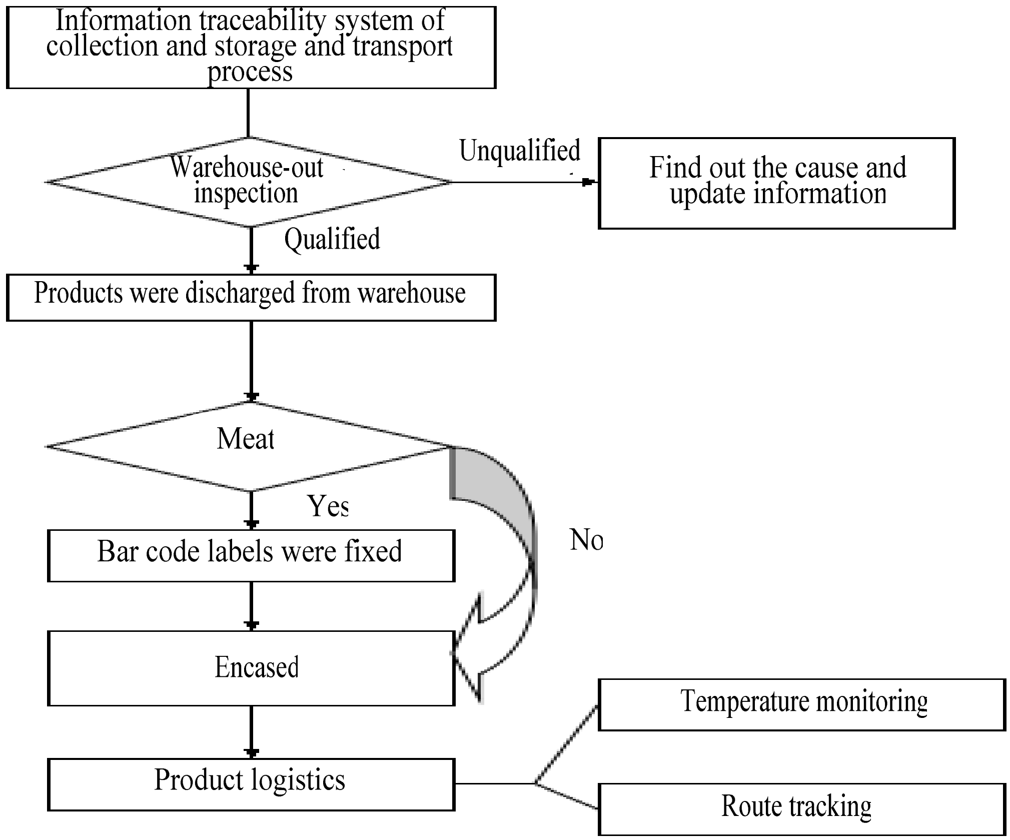

Figure 3. Flow diagram of storage and transport link of fresh agricultural products

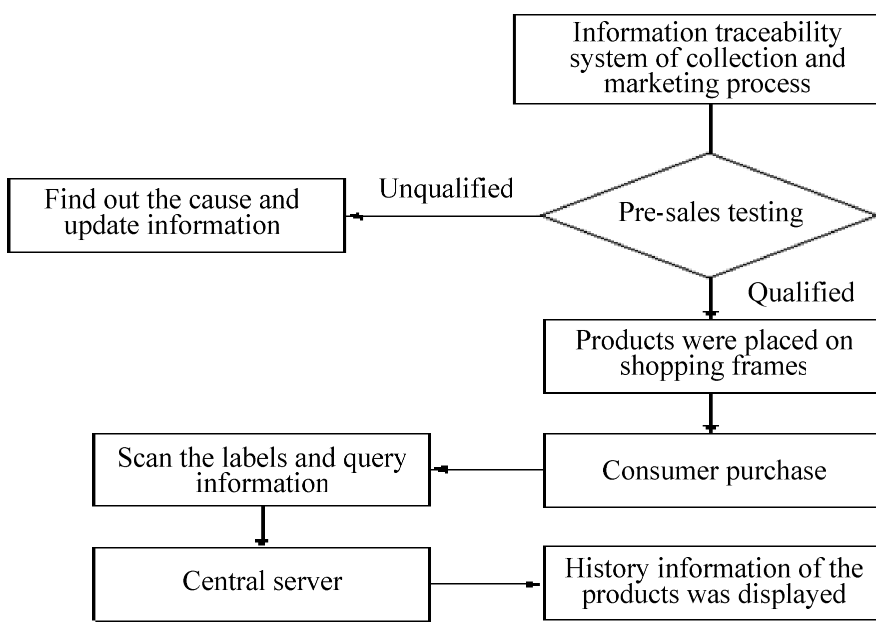

Figure 4. Flow diagram of the marketing link of fresh agricultural products based on bar code

As can be seen from the flow chart, if consumers bought the fresh agricultural products, they could use bar code labels as the medium and retrieve the historical information of the products through the central server, which allowed the consumers to have a better understanding of the QS information of the products and make rational choices in purchasing.

2.3. Construction of quality safety traceability system for fresh agricultural products

2.3.1. Construction steps of the system

First, the core database system of the fresh agricultural products was designed. Next, the quality safety evaluation system of fresh agricultural products was established. Then, the origin traceability system of fresh agricultural products was established, followed by the establishment of thematic information mapping system. At last, the traceability system platform for product supply chain safety was established (Samarasinghe et al., 2009).

2.3.2. Functional design of traceability system

The traceability system of fresh agricultural products consisted of information collection, query and marketing. Information collection module included user management, producing area management, acquisition and processing management, logistics management. Information query included consumer query and regulation of management departments. Marketing information module included inventory management, marketing management and early warning. The information of information collection module could be read and transferred to traceability information database automatically with radio frequency identification technology.

2.3.3.Software architecture design of traceability system

The traceability system of fresh agricultural products mainly included user interface layer, exterior layer, business layer, data access layer and database. User interface layer was used for displaying the fresh product information that met the requirements of users; exterior layer acted as the interface of traceability system to isolate business logic; business layer functioned by establishing business components according to management objects and calling the defined services to construct corresponding applications; data access layer was the data interface for business layer of traceability system to enter and access the central database. Database was used for storing the information of key links (such as the breeding process of beef cattle, slaughter of beef cattle, processing of beef, beef storage and marketing), thus to provide reliable information on quality safety of products for the access to terminal applications (Pereira et al., 2015; Jacob et al., 2010).

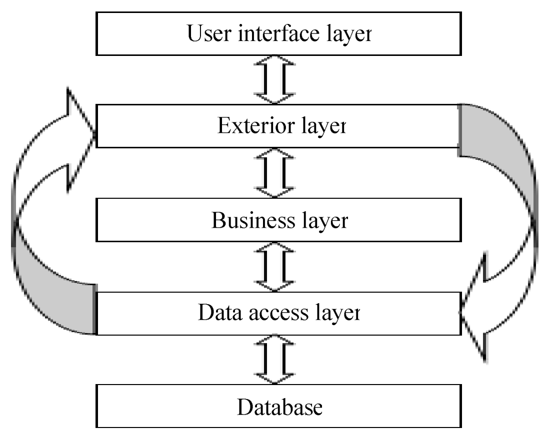

Figure 5. Overall software architecture of traceability system

2.4.Construction and implementation of quality safety traceability system of fresh agricultural products

2.4.1. Development of production subsystem

Supervision departments and consumers could inquire detailed information of production link of fresh agricultural products via the system terminal. After harvest, fresh agricultural products had to be examined and proved qualified by relevant departments before they flew into the next link. The framework of production subsystem is shown in Figure 6. In terms of the production process of beef cattle, the information that needed to be recorded included farm information, breeding mode, beef cattle varieties, source of calves, fodder, cowshed disinfection, epidemic situation, quarantine level and slaughter dates (Bene et al., 2010; Mummed et al., 2013).

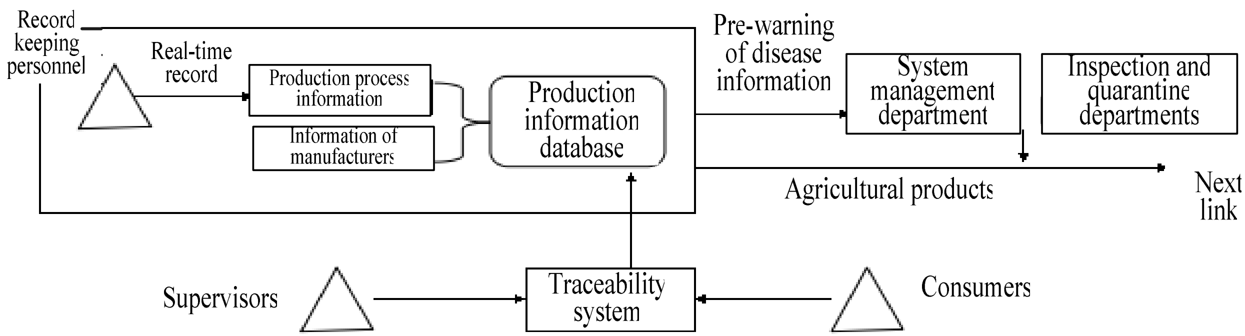

Figure 6. Framework of production subsystem

2.4.2. Development of processing subsystem

The processing subsystem of fresh agricultural products required real-time recording of detailed information of fresh agricultural products in the process of collection and processing; and then, the information was timely input to the information database of processing link, so that regulation departments and consumers could inquire the detailed information of processing link. The frame diagram is shown in Figure 7.

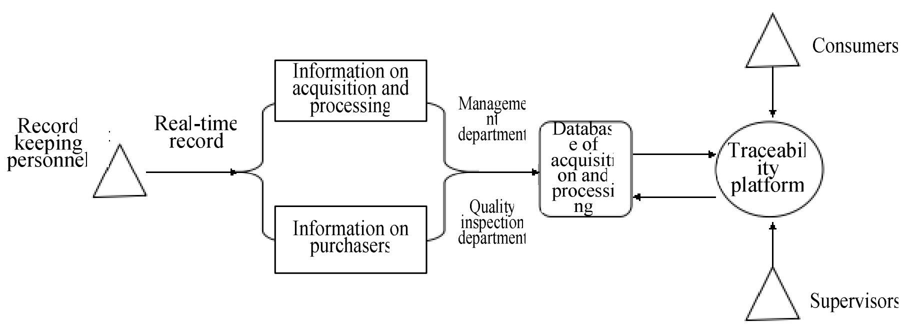

Figure 7. Architecture of processing subsystem

Beef processing involved pre-slaughter, slaughter, acid drainage, joint separation, packaging and storage.

Controlled objects in the processing chain included logistics and information flow: logistics referred to the one-way flow from pre-slaughter to storage, while information flow was a two-way flow, as shown in Figure 8.

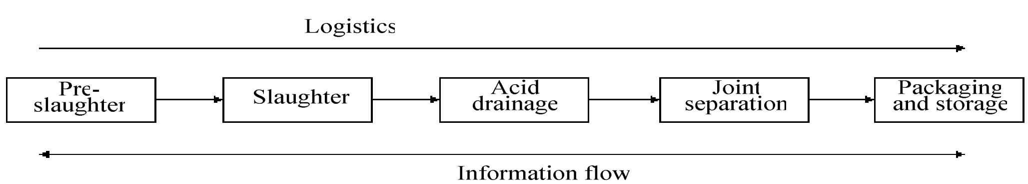

Figure 8: Logistics and information flow in beef processing chain

2.4.3. Implementation of traceability system

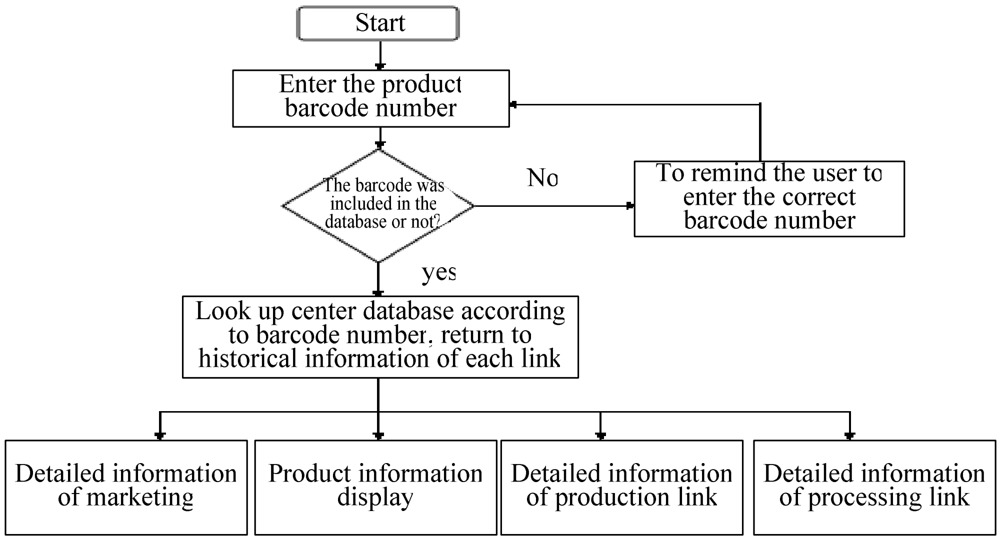

Figure 9. Module function flow chart of the traceability system

2.4.4. Implementation of product information query interface

When users input effective barcodes in the tracing interface, they could obtain corresponding history information of the barcodes. The query interface mainly displayed the product information on breeding, processing and marketing, including bar codes, product names, origin, prices, grades, security level, expiration date, manufacturers, slaughter processors, vendors, product number and marketing situation. In addition, the interface also displayed associated controls of the information on production, processing, marketing, system management and security pre-warning. By clicking on the corresponding associated controls, users could view the corresponding historical information (Karni et al., 2015).

2.4.5. Implementation of information query interface of production process

By clicking on the associated control of production information, users could enter the production link information query interface which would display the historical information of the products in production process, including production unit, address, contact information, breeders, breeding objects, drug use, barcode numbers and examinations on the breeding objects (Hao et al., 2016).

2.4.6. Implementation of query interface of marketing link

In the product information interface, by clicking on the associated control of marketing information, users could enter marketing link query interface which displayed the information of vendors, marketing corporation, address, contact information, product names, product codes, marketing status and product inventory. With quality safety traceability system of fresh agricultural products, users could inquire the detailed historical information of the products in the process of production, processing and marketing by inputting the product barcodes, which improved information transparency of the products and guaranteed the rights to know of consumers (Dewhirs et al., 2015).

3. Conclusions

Firstly, the performance requirements of traceability system were studied; then, the modeling theory of Petri net (applied in the modeling of traceability system) was analyzed (Sara et al., 2015). Furthermore, the customer demand for quality safety traceability system of fresh agricultural products was analyzed. Based on Petri net modeling method, this study implemented the design of information models for the key links (feeding, storage and transportation, marketing), and performed modeling analysis on the whole traceability system (Peyraud et al., 2011). On the basis of requirement analysis, system model and the overall goal of the traceability system, this study designed the technical route, functional module and software system architecture (Corazza et al., 2016). Finally, design and development of the traceability system were performed, including the development of production subsystem and processing subsystem. Via successful connection with the database, display interfaces for production information, query information and marketing information of fresh agricultural products were obtained (Wang et al., 206; García-Sandoval et al., 2016).

In summary, construction and implementation of the quality safety traceability system for fresh agricultural products not only improved the transparency of QS information of fresh agricultural products, but also enhanced information sharing and authenticity effectively (Chiang and He, 2010). With the help of quality safety traceability system, enterprises, supervision departments, sales departments and consumers could inquire the information of fresh agricultural products by entering barcode numbers, thus to safeguard their rights and interests.

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