Design and Application of Quality Traceability System Based on RFID Technology for Red Jujubes

Fenghua Huang, Shujuan Zhang, Huaming Zhao

Design and Application of Quality Traceability System Based on RFID Technology for Red Jujubes

Fenghua Huang [1], Shujuan Zhang [2], Huaming Zhao [2]

1. College of Information Science and Engineering of Shanxi agricultural University; 2. Engineering College of Shanxi agricultural University, Taigu, Shanxi, 030801, China[1]

zsujuan@263.net

Abstract. The traceability system is regarded as an effective method to ensure safety quality for farm products by many countries all over the world. Although this system is common for a range of farm products, few reports for red jujube are available nowadays. Our study focuses on constructing a traceability system in terms of information technology in order to implement quality tracing for red jujube products for the first time. Based on the RFID technology, QR (Quick Response) codes and EAN/UCC-128 barcode technology, this system was established in detail by analyzing the whole sector data such as land management, planting and picking, processing and packaging, transporting, selling of products and so on, which formed the traceability information. It was also put into SQL2005 database system and C# was used to develop the quality traceability system based on C/S for red jujubes. From this research, we can see it is beneficial and easy to thoroughly master the quality and safety information of red jujubes from production to circulation for manufacturers and customers by this system.

Keywords: Traceability system; RFID; EAN/UCC-128; QR code; Red jujubes

1 Introduction

During recent years, poor food quality has occurred frequently such as milk powder containing Melamine in 2008, Changli counterfeit wine in Hebei province in 2010, Shuanghui lean meat adding "Lean meat power", and dyed mantou. In addition, some diseases, mad cow disease, foot-and-mouth disease, bird flu, which affect food safety, also broke out now and then. Poor food quality not only does harm to Chinese's health, but also affects the export of agricultural product and food in China. According to international rules, some developed countries, America, EU, etc, set regulations that some imported food to their countries must be traced back. Consequently, trade barriers to Chinese food and agricultural products are formed. Hence, it is urgent to set food traceability system for breaking trade barrier for food and enlarging international export.

Red jujube in Taigu County, Shanxi province, especially Huping Jujube is very popular in local areas because of its largeness, thin skin, and nice chewy texture. But it also faces questions of planting, untraceability of processing, and

food safety. Hence, traceability system should be set to improve the transparency of food safety and to improve its competitive ability.

The study of traceability system, a response to mad cow disease, was first set by EU in 1997. At the end of 2000, EAN International established new "beef label law" which was first carried out by Meet Export Group in EU, and applied EAN.UCC system to the producing and supplying chain of beef [1,2]. In July, 2002 EU issued a decree that all food sold in EU should be able to be traced from 2004, and *Regulations of Food and Fodder Safety in EU* should be carried out in the early of 2006, which emphasizes the control management of food from farm to table and its traceability[3]. Over 40 years ago, America set laws for chemistry remains in food [4]. The Congress heightened food safety to country safety level, so the government made compulsory administration to food safety and enterprises were asked to set the production traceability system [5]. The modernization of food safety was realized from tracing and checking production to prevent the pollution of meat and bird food [6]. The traceability system of agricultural product in Japan was the most advanced, which focused on product information, attracting consumers' most attention, such as the information of applying fertilizer in fruit plant and the information of spraying fruit with insecticide etc. [7]. With the driving of government, other food traceability system except beef was set in Japan from December, 2004[8].

At abroad, the constructive goal that traceability system of vegetable safety in Beijing will be primitively set and tracing mark of vegetable safety should be applied to 20 enterprises which process and distribute vegetables was put forward by Beijing city government [9]. The control and traceability system of Olympic Games food safety was first used on 8_{th}, August, 2007, which effectively guaranteed food safety during Olympic Games. On 5_{th}, March, 2009, Prime Minister Wen Jiabao gave a report in the second conference of 11_{th} NPC, and he claimed that one of the main tasks in 2009 was to strictly implement the system of market access, traceability system of product quality, and the system of recalling poor quality product[10] so as to heighten the constructing traceability system in our country to a new level. At present, food traceability system has been or is being established in many areas and provinces. In 2004, vegetable traceability system was tried in the vegetable base in Shouguang, based on the cooperation of State Bureau of Quality Testing and Shandong Bureau of Quality and Technical Supervision etc [11]. In 2003 Jufang Xie etc. studied pork traceability system [12]. Based on Web cultivating quality of Tilapia, Xi Ren in Chinese Agricultural University studied traceability system [13]. Besides, some universities such as Chinese Academy of Agricultural Sciences, South China Agricultural University, Shanghai Ocean University, Nanjing Agricultural University also studied traceability system for pork, beef, and mutton [14-19].

All the studies focused on livestock product, and these systems can only trace back to production enterprises. So according to red jujube producing in Taigu county, this paper aims at establishing a set of database which consists of production base, product, and certification and supervision information to supervise jujubes, identify the production base of jujubes, and to evaluate

production environment. This research also focuses on developing traceability system for government and enterprises to realize the government's certification and anti-counterfeiting administration for red jujubes in Taigu county.

2 The Design of System

2.1 The Design of System Structure

As is shown in figure 1, the system is divided into seven subsystems according to the supply chain of produce together with planting, processing, inspection and quarantine, sales information, process of tracing of red jujubes in Taigu. It used C/S structure and the central database was maintained by relevant government departments.
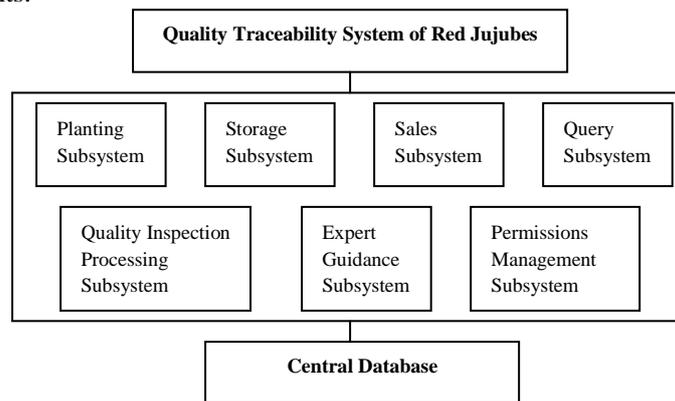

Fig. 1. The structure of traceability system

When the system is registered by the users, the administrator can fully control it. Other users can only upload and access to their own subsystem data and public data. Query subsystem doesn't need to register.

2.1.1 Planting Subsystem
Planting subsystem includes information of planting base, farmer's information, environment monitoring information of planting base, plant drugging information, fertilizing information etc.

The special information administrators are responsible for the input of planting information of each village's cooperatives. Each information administrator has RFID CARDS. They can input information and manage the module by registering with the card.

Information administrators record information of red jujube tree species,

tree-age, fertilization type, fertilization date, fertilizer quantity, drug types, drug date, drug quantity and so on and put them in the system. They also have the responsibility to guide planting of red jujube and management and the purchase, storage and safe usage information of fertilizers. Through understanding the information of expert guidance subsystem, information administrators convey guidance of experts in time to each village and provide guidance to applying of fertilizers and pesticides. The system's database provides certain limits to the amount of fertilizers. If there is excessive drug uses after the information recording, the system will give some hints in order to be corrected immediately.

Unified numbers are given to each piece of red jujube planting cooperatives and each field has its own RFID tag used to store information of the plot and varieties of red jujubes. When red jujubes are picked, the RFID tags should be fixed on the storage bag in order to trace the information.

2.1.2 Storage subsystem

Storage subsystem includes the time of warehousing, outbound time, deliver destination, warehouse numbers, temperature, humidity, health monitoring and other information of each batch of red jujubes. It services the red jujube processing enterprises and it's the responsibility of the enterprises to maintain the information in the database.

Storage subsystem includes processing of red jujubes before and after storage. After the red jujubes are picked, they are transported to the local constant temperature warehouse for processing. The gates of the warehouse are equipped with electronic label RFID readers. Before warehousing, the reader will read the information of origin in the electronic label and automatically generate storage time, which is stored in the database. Red jujubes are drawn according to processing needs. Passing the gate, RFID tags are reread and the outbound time is generated automatically. After processing, the finished products are transported to the finished-product warehouse, with a RFID tag attached to each batch. By reading the tag, the database automatically adds the additional information to the information stored last time and forms complete information of database for this group of red jujubes.

2.1.3 Quality inspection, processing subsystem

Since each batch of red jujube has to be screened and divided into various grades, it uses two-dimensional code for information traceability in order to reduce production costs and add information easily. When the red jujubes are transported to the processing plant from the warehouse, the RFID reader will firstly read the corresponding tag and then generate the corresponding two-dimensional QR code according to the database information. Then the red jujubes are classified by its size, cleaned and disinfected. After that, the new processing information will be added to the two-dimensional code. Processed red jujubes will be sent into fruit inspection and quarantine center for pesticide residue inspection, and sampled according to the national standard indicators of fruit sampling. If they don't meet

the needs, they will be sent directly to waste-processing sector. The inspection information will be added to the two-dimensional bar code of the qualified red jujubes and generate corresponding inspection information. These red jujubes are stored in the finished-product warehouse waiting to be sold.

2.1.4 Sales subsystem
Sales subsystem serves local sales agents or supermarkets, which have a unique radio frequency identity card. Authenticated by the RF card, they can read the two-dimensional code on the packaging of the red jujubes distributed to their stores after registering and bound the information of red jujubes with the sales information. When the final trace information is completed, the one-dimensional trace code will be printed and affixed to the packaging of the product for sales.

2.1.5 Query Subsystem
Query subsystem serves the vast numbers of consumers. After purchasing red jujubes, consumers can query and trace product information through various means. By inputting the one-dimensional code, consumers can access WAP network via internet or mobile phones. Consumers can also trace the product by reading the two-dimensional code on the package through phone camera with two-dimensional code decoding software. They can also call 800 tracing phone. A complete product traceability information can be got through any of the ways mentioned above.

2.1.6 Expert guidance subsystem
This system can not only trace product information, but also provide expert guidance system for planting red jujubes. Expert guidance subsystem offers a variety of technical guidance and video files for majority of red jujube growers and co-workers as to how to plant red jujubes. The system also provides fertilizing, spraying, pruning information in different stages of planting red jujubes. The administrators are responsible for conveying the information to each village.

2.2 Design of System Database and Interface

The amount of data collected by this system is approximately from 5000 to 50000 every day. In order to achieve higher stability and easy maintenance, Microsoft SQL Server 2005 database is the most appropriate choice. Windows 2000 / XP/windows7 is chosen as operating system of the client Software, whereas Windows 2003 is used as operating system of Server. The technology of reliable Hot Standby should be used to ensure data security by duplicating data regularly.

After the system clients are installed, user can login the system by entering user name and passwords, selecting the corresponding user types, and then clicking the submit button. If all the items are correct, system will change into the

corresponding subsystem or Query Interface, as shown in figure 2.

Fig. 2 Trace back system information query interface

The system provides a variety of ways to search the terminal. Firstly, user can use touch-screen terminal provided by supermarket to query, once the traceability code of one-dimension labeled on the goods is inputted into the system you can view the information to be traced. The results on touch-screen terminal are shown in Figure 3. Secondly, two-dimensional code on the packaging of goods can be taken by mobile phone and sent to China Mobile service platform 700066 to query. Thirdly, user can login trace website provided on the package to query, just entering the traceability code of 28-digit number one-dimensional, query information can be generated. Fourthly, user can query via mobile phone by inputting WAP site labeled on the packaging, which has the same effect as www sites. No matter what query modes, the system will provide detailed traceability information.
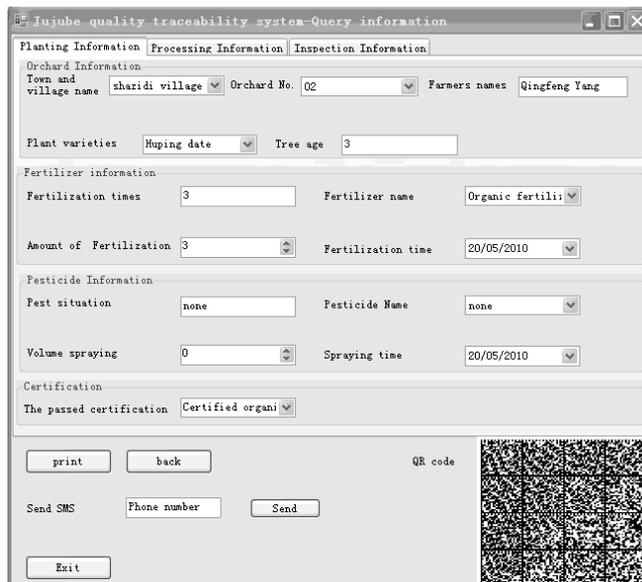
Fig.3 The red jujube cultivation information queried by tracing system

3 Design of System Barcode

RFID tags are used in the trace chain. Generally there are two ways: one is that the information stored on the RFID tag. Information is extracted from RFID tag when it is traced. This method is easy to extract information, but the label's storage capacity is limited, not covering all the information of the whole logistics process; another way is that agricultural information is stored in the online database, so using RFID tags as the index to access information has the better scalability. If a two-dimensional code is used as an information carrier after processing, it has more cost-effect [20]. Based on RFID tag traceability system for agricultural products, it constitutes three aspects, agricultural production, processing, and circulation. The system of agricultural production during producing uses RFID tags to store information, and combines processing with circulation to produce two-dimensional code to the record information.

The system uses the most common EPC-96 as the Electronic Product Code, to record agricultural information in producing. EPC-96 has 96-bit memory storage capacity. To facilitate the expansion of the system in the future, it sets aside out of 36 bits as an extension bit. The remaining 60 bits are used to record red jujube about village information, cultivated land information, batch information, picking date information and so on. The information of original place accounted for 36 bits, and date information accounted for 24 bits. As land-related information is already stored in the database, system can inquiry variety planting information of the batch red jujube, if the label stores into the origin and processing connects with the database.

3.1 Original place code

According to the Ministry of Agriculture promulgated the *Rules of Farm Produce Original Place Code* (standard number: NY / T 1430-2007), farm producing origin code are composed of county and above-county administration and constituted of 20 decimal digits [21]. If the 20 decimal numbers are directly transferred into binary bits, which need 63 bits, RFID tags can not directly store original place code. The system needs choice and coding, as the use of the system is now concentrated on Taigu County, and all red jujube are produced in various towns in Taigu, so classification code of county and above the county is directly cancelled, which means encoding from the town.

According to GB/T10114-2003 *the Establishment Rules of Code Divisions in the Following County-Level Administrative*, the code of county-level administrative consists of nine-digit number, separating into two parts. The top six of first paragraph is six-digit of the GB/T2260 code, representing the county

administration. The second paragraph is constituted by three digital [22], representing below-county administration. The last three digits in the rules are used as the top three digits in the new coding, which represents town code of origin planting red jujube. Behind the township code is village and block coding, and the system codes number of villages according to Taigu County township: 01-99, meanwhile the same number code of each block is also: 01-99. For example: Taoyuanbu village, Houcheng town, Taigu county, the number of original planting place is: 1044901, (Taoyuanbu village No. 49 in the system), so the binary code is: 0001 0000 0,100,010,010,010,000 0001.

3.2 Picking date code

The code of picking time selects six bits as the date code, such as the September 1, 2010, is replaced 100 901 code. But it should be 24 bits in the tag, that is 0001 0,000,000,010,010,000 0001 after encoding.

3.3 The design of two-dimensional QR code

The system selects QR Code as two-dimensional barcodes based on the actual situation in China and selects M-class as correction level based on the requirements of traceability design and information. Two-dimensional QR code should show much detail information during the whole traceability process, which includes planting, testing, processing, selling information and so on. They are stored within the two-dimensional code, and the resulting two-dimensional code is as Figure 4.
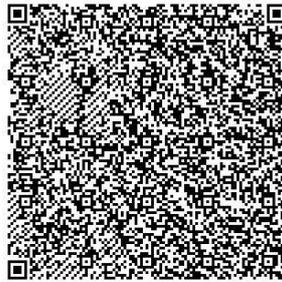

Fig.4 QR bar code generated by traceability system

3.4 One-dimensional traceability code

The system traces information with EAN/UCC-128 as the last bar code, which is required to link with a database when using it, so the bar code information includes original place of red jujube, batch picking, picking date. The three kinds

of information can determine the other information of red jujube. For example, the third batches jujubes are picked on September 16, 2010, in 02 orchard in Shazidi village, Xiaobai town. The code of Taigu county Xiaobai town is 140 726 112, 01 for number of Shazidi village, 100916 for picking date code, 03 for batch coding, so the corresponding one-dimensional trace code is: (10) 03 (11) 100 916 (251) 1407261120102, generating one-dimensional back yards in Figure 5.

Fig.5 The resulting one-dimensional bar code created by traceability System

4 Conclusion

The research and application of red jujbes product quality and traceability systems will improve the traceability system of agricultural information, and play an increasingly important role in agricultural products trade and consumption market, it is a important measure to ensure agricultural products quality and safety.

This paper selects traceability system of agricultural products as the research object. Based on the successful experience of domestic agricultural products about traceability system and a lot of red jujube datas about quality and safety standards and detailed information at various stages, producing stage, processing stage, and selling stage, this paper deeply explored traceability system for the quality of Taigu's red jujube. It filled the gap of product quality and traceability system, and provided the base of the rules and technical guidance for enterprises and governments for the quality and safety of agricultural products. The main conclusions are summarized as follows:

(1) After analyzing the domestic agricultural supply chain, every link of red jujubes in Taigu, planting, storing, processing, and selling is digitized and standardized, and proper information data for management system is established to provide more perfect and possible data collection system for domestic red jujube market.

(2) The overall framework of a red jujube supply chain system is built, and the traceability method of red jujube products are investigated, eventually the spatial structure and the overall functional structure of red jujube quality traceability system are proposed.

(3) A technology based on RFID and the concept of traceability, which combined one-dimensional bar codes with two-dimensional bar codes, is proposed. Traceability information can not only achieve the purpose of tracing information, but also overcome the high cost only when using RFID technology, and overcome shortcomings of easily defacing only when using bar code technology. And this article built various traceability methods including WAP

network to facilitate consumers' inquiring.

Acknowledgement

References

1 Diekinson DL,Dee DeeVon B.Meat traceability:Are U.S.consumers willing to pay for it [J]．Journal of Agricultural and Resource Economies, 2002, 27(2): 48-364.

2 Massimo B，Maurizio B，Boberto M，et a1.FMECA approach to product traceability in the food industry[J]Food Control,2004,17(9): 1-9．

3 Food Traceability.Health & Consumer Protection Directorate General. 2007, 07.

4 Diogo M.Souza-Monteiro and Julie a.Caswell Implamenting Traceability in Beer Supply Chains.Depertment of Resource Economics of University of Massachusetts Amherst Working Paper 2004-6.June, 2004.

5 Xinting Yang, Jianping Qian, Beilei Fan,et al. Establishment of Intelligent Distribution System Applying in Logistics Process Traceability for Agricultural Product[J].Transactions of the Chinese Society for Agricultural Machinery,2011(5),125-130.

6 Xing Zhou. Design and Implementation of Iformation Safety Certification System of Agricultural Products [D]. Wuhan: Huazhong Agricultural University, Master's Degree Paper, 2008, 10-11.

7 Ming Li. Research of Traceability System of Agricultural Products of Safety [D]. Beijing: Tongji University, Master's degree Paper, 2007.

8 Xinting Yang, Jianping Qian, Chuanheng Sun,et al. Design and Implementation of t Traceability system of vegetable safety product ion [J], Journal of Agricultural Engineering, 2008 (3) 24:162-164.

9 Lifang Wang, Changhu Lu a, Jufang Xie, et al. Research of Livestock and Livestock product Traceability System [J]. Journal of Agricultural Engineering, 2005, 21, (7): 168-174.

10 Jiabao Wen. The Government Work Report of the Second Meeting 11_{th} National People's Congress. 2009, 3.

11 Yinghui Zhou, Xianhui Geng. Application of Traceability Systems in Food Quality and Information Security[J]. Agricultural Modernization, 2002, 23 (6) : 451-454.

12 Jufang Xie. Junhua Liu. Research of Traceability System of Agricultural Product Quality Status, Problems and Countermeasures[J]. Business Times, 2009 (25): 66-68

13 Xi Ren, Zetian Fu, Weison Mu g, et al. Design of Traceability System of Based Web Information on quality and safety of Farmed Tilapia [J]. Journal of Agricultural Engineering, 2009, 25, (4): 163-166.

14 Shunan Zhang. Research of Chilled Pork Supply Chain Tracking and Tracing System [D] Beijing: Chinese Academy of Agricultural Sciences, Master Paper. 2008.

15 Lihong Jiang. Research of Pork Quality Safe Traceability System [D] Shanghai: Shanghai Ocean University, Master Degree Paper, 2008.

16 Shougang Ren, Huanliang Xu, An Li, et al. Design and Implementation of Meat Traceability System Based on RFID / GIS[J]. Journal of Agricultural Engineering, 2010, 26, (10); 229-233.

17 Standards Press of China. Assembly of National Standards Barcodes [M]. Beijing: China Standard Press, 2004.73-74.

18 Xiaoping Wang, Yuf An a.Research on the Logistics Information Tracing System of Vegetable Agricultural Products[J]. China Business and Market,2011,25(3):34-37,128.

19 Lei Wang, Feng Wang. Analysis on the Barriers for Implementation Traceability System into Agricultural Product—a Framework Based oft SCP Form[J]. Lanzhou Academic Journal, 2010,(8):40-42,77.

20 Xiaoguang Zhou, Xiaohu Wang a. Radio Frequency Identification (RFID) Technology Principle and Application Examples [M]. Beijing: People's Posts and Telecommunications Press, 2006.

21 He Wang, Research of Strategy of China Mobile Phone in Two-Dimensional Coding [D] Beijing: Beijing University of Posts and Telecommunications. Master Paper, 2010. 23- 24.

22 Shenglin Zhu, Shouquan Zhang, Wei Peng. Design and Implementation of Pork Traceability Certificate Management System [J]. Research of Agricultural Modernization, 2010, (11):99-104.