TRACEABILITY SYSTEM FOR AGRICULTURAL PRODUCTS BASED ON RFID AND MOBILE TECHNOLOGY

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ABSTRACT

We developed a traceability system for agricultural products, based on the innovative technology, RFID (radio frequency identification), and mobile phones. This system is called the "Application For Agricultural Methodological Analysis" (AFAMA), an Internet-based system for managing the agricultural production process. Using Internet-enabled mobile phones, farmers can easily input records about farm activities and material applications during outdoor work. In order to identify individual products on the distribution process more efficiently, we applied small RFID tags with unique ID numbers. Each RFID tag on a product relates to its production data on the AFAMA database. In the distribution process, workers read the RFID tags using RFID readers, and transit records of the products are inputted to a database. Field experiments of this integrated traceability system were performed on fruit and vegetable products, and information disclosure about them were well received by consumers.

Key words: traceability system, RFID, mobile technology, Japan

INTRODUCTION

The Japanese people have become increasingly concerned about food safety problems. Thus, in order to guarantee safety, a food traceability scheme that discloses information about food production and distribution processes has to be established. Toward this end, the Japanese government, local governments and the Japan Agricultural Cooperatives (JA) have been promoting the development and practical application of food traceability systems (FTS) as national projects.

Several FTS based on information technology (IT) have been developed in recent years. The "Virtually Identified Produce System" (VIPS) is the basic scheme of FTS, where ID numbers are given to food products and printed on their labels or packages. Farmers input in the production data about their products to an Internet-accessible database. Consumers who purchase these products can browse a product's data by going to the VIPS Website and entering the product's ID. Based on the VIPS, a practical information disclosure system called "SEICA" for fruit and vegetable products was developed and opened to the public in 2002 (Fig. 1).

Recently, a noncontact automatic identification technology, RFID (radio frequency identification), has shown promise for a more advanced and effective FTS. We developed an integrated traceability system for agricultural products to uniquely identify each product and store its information from production to consumption, applying an innovative technology of Web-based network computing, RFID and mobile phones (Fig. 2). This system consists of three subsystems, as follows: production record system using Internet-enabled mobile phones; distribution record system using RFID tags and readers; and information disclosure system for consumers.

PRODUCTION RECORD SYSTEM

Typing in the data on farm management is a troublesome task for farmers. In Japan, mobile phones and Internet services are very popular among farmers. Thus, we developed a labor-saving and efficient system called "Farming Diary System" for managing the agricultural production process using Internet-enabled mobile phones (Sugahara 2001). As a commercialized adaptation of this system, we developed a Web application software,

Fig. 1. Scheme of the information disclosure system for fruit and vegetable products, "SEICA".

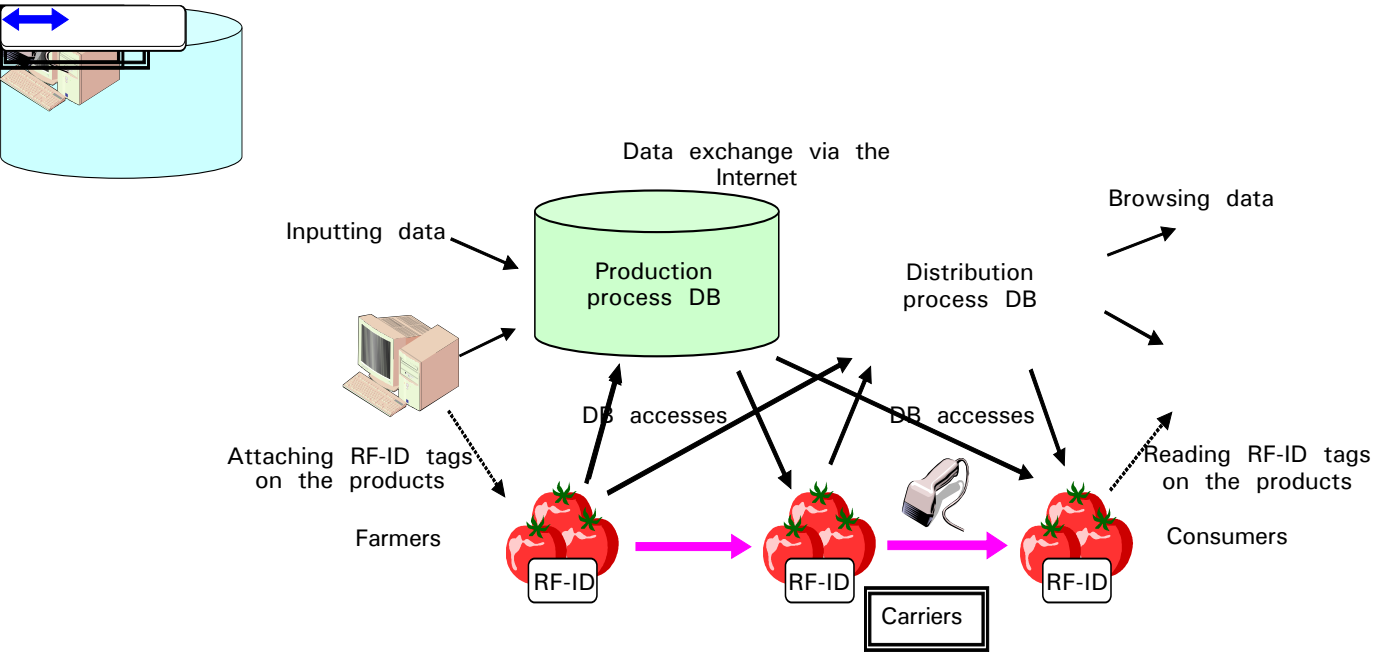
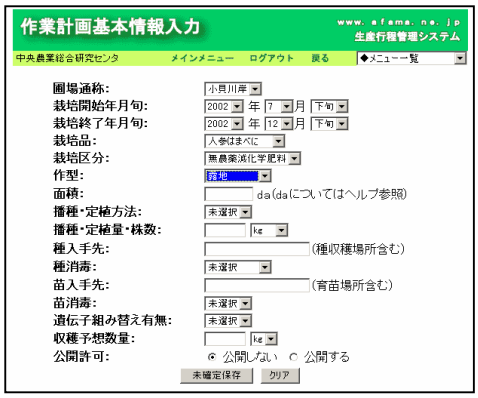


Fig. 2. Concept of the integrated traceability system for agricultural products to record and store data on the production and distribution processes, using RFID and network computing.



A display of the schedule setting page on a web browser of PC.

A display of the list page of production records on a web browser of PC.

Displays of the data inputting pages on an Internet-enabled mobile phone.

Login page

Pesticide inputting page

Fig. 3. The production process management system, "AFAMA".

"Application For Agricultural Methodological Analysis" (AFAMA) in 2002.

Using mobile phones and accessing the web server of AFAMA, farmers, as the users, can easily input their production process data such as farm activities and material applications (pesticides, fertilizers, etc.) on their cultivated fields during outdoor work (Fig. 3). The data are stored in the database of AFAMA. The individual users can customize the selectable input items such as crops, fields, tasks and materials.

The following are the steps in using the AFAMA:

1. Access the AFAMA Website using a mobile phone or personal computer, input user ID and password on the top page and log in.
2. Input private data to customize one's crops, fields, tasks, agricultural materials, machines and so on in advance.
3. Input the schedules of cultivation and material applications on the fields.
4. Input the operation data to select the customized and scheduled items.
5. Browse and print these inputted data.

DISTRIBUTION RECORD SYSTEM

A basic element of a food traceability system is that unique ID numbers are given to products and ID labels or tags are attached to them (Sugiyama 2004). In order to identify individual products and record their transit data in the distribution process more efficiently and quickly, we developed a distribution record system based on the RFID technology (Fig. 2) and we applied small and inexpensive RFID tags with unique IDs ("mu-chip") and RFID readers provided by Hitachi Ltd.

The procedure in using this system is as follows:

1. Production records on the agricultural products, which farmers have written or typed in, are stored in an Internet-accessible database.

2. IDs of RFID tags are registered and related to the production data on the database in advance. Before the shipment of the products, these tags are attached to a product lot such as a package, box, container or pallet.
3. At some stages of the distribution process such as wholesale markets, delivery centers and retail stores, records of the arrival, departure, mixture and subdivision of individual lots are inputted into the database via the Internet, by reading the RFID tags on the lots and checking their IDs.
4. The users can browse the data on the individual products via the Internet, by reading the RFID tags.

INFORMATION DISCLOSURE SYSTEM

It is required to disclose proper information about agricultural products to consumers. We developed an information disclosure system based on VIPS, and additionally, we applied an automatic identification technology such as RFID and barcode. The IDs of RFID tags or barcodes attached to the individual products relate to the data on the production and distribution process databases. Consumers who purchase the products can immediately browse their production and distribution data and additional information via the Internet, when they read the RFID tags or the barcodes, using Internet-accessible devices with RFID readers or mobile phones with barcode-reading function. Incidentally, camera-equipped mobile phones are very popular in Japan and many of them have barcode-reading functions.

FIELD EXPERIMENTS

Pears in Yamagata

In cooperation with farmers, a wholesale market, a cooperative society (co-op) and the Yamagata prefectural government, we conducted field experiments of the integrated traceability system on pears in November 2003 and on strawberries in February 2004 in Yamagata prefecture. In these experiments, RFID tags (mu-chip), which had been coated with polyethylene (PET) plastic in advance, were used (Fig. 4).

First, the farmers who had grown pears or strawberries inputted production data on their own fields, using their mobile phones and accessing the AFAMA system. The harvested fruit products were shipped to the wholesale market. There, the fruits were packed in cardboard boxes and RFID tags, related to the product IDs and the production data, were attached to the individual boxes (Fig. 5). They were checked at some stage from the wholesale market to the co-op store, and their IDs and transit time were inputted to the database. In the store, Internet-accessible display terminals with RFID readers were installed. When consumers selected the products to purchase, they could easily check the production and distribution data, by reading RFID tags on the products (Fig. 6). These tags were collected at the cash registers to reuse them.

On the other hand, the labels on which two-dimensional (2D) barcodes were printed (Fig. 4), were attached to gift boxes of pear products that were directly delivered from the wholesale market to consumers. These barcodes coded the URL, including the product ID number. Using the barcode-reading function on mobile phones and accessing the URL, consumers could browse the production and distribution data of the products. These field experiments of the traceability system were well received by consumers.

Spinach in Saitama

In cooperation with a vegetable farmer company, a co-op group, Saitama prefectural government and the National Agricultural Research Center, we conducted a field experiment of the integrated traceability system on spinach in November 2004 in Saitama prefecture. In this experiment, RFID tags (mu-chip) were attached to individual products in order to identify each of them, and mobile RFID-reading devices consisting of PDA and card-type RFID readers were used.

First, the farmers who had grown spinach typed in the production data of their own fields using the AFAMA system. The harvested products were put into plastic bags, and paper cards, on which RFID tags (bag tags) were pasted, were inserted into the individual bags (Fig. 7). These bags were put in container cases on which RFID tags (case

Fig. 4. RFID tags, and a barcode label which were used in the practical experiments.
A: An RFID tag with a microwave antenna, ("mu-chip") provided by Hitachi Ltd.
B: A tag made of mu-chip which is coated with PET plastic.
C: A label on which a 2D barcode and URL including product ID are printed on.

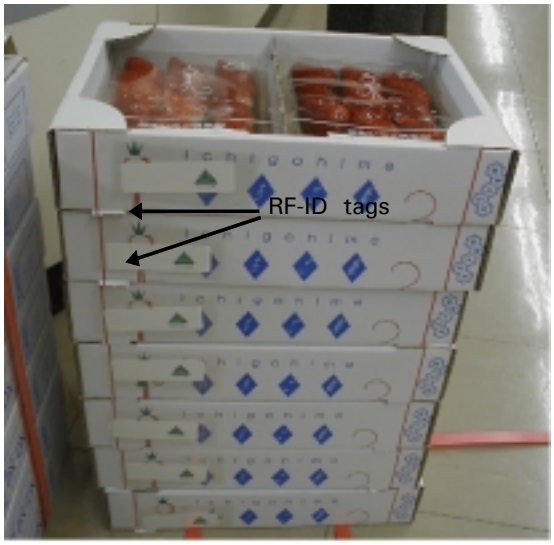


Fig. 5. RFID tags which are attached on to the cardboard boxes containing strawberry fruits at the wholesale market.

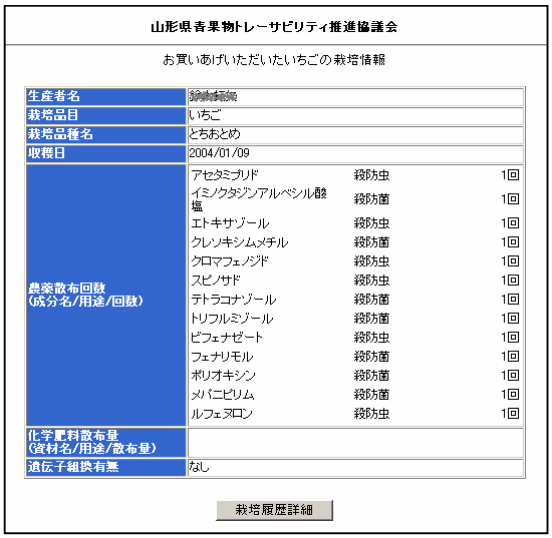


Fig. 6. A web application for information disclosure on the strawberry products. This display shows frequency of pesticide applications on the production process of the strawberry products.

tags) were pasted. Farmers read the bag tags and the case tags in order to record their IDs and relate them to each other. Before these products were shipped to a co-op delivery center, the farmers read the case tags to record the shipment. In the delivery center, the case tags were checked at some stage (Fig. 8), and their IDs and transit time were inputted to the database. These products were directly delivered to consumers from the delivery center. The consumers who cooperated in this experiment, by reading bag tags attached to the products, could check the production and distribution data (Fig. 9).

DISCUSSION

The production record systems, AFAMA and similar application software have already been utilized in many agricultural sites. To let more farmers use the systems and input production data more positively, we are developing functions to provide information to support appropriate farm tasks such as application of pesticides and fertilizers.

Regarding the distribution record system, it is costly to utilize RFID tags and reading devices and to handle RFID in tagging and reading. To solve these problems, we are studying how to reduce the cost and automate RFID handling.

On the field experiments of the integrated traceability system, information disclosure on the fruit and vegetable products was well received by consumers. But it was difficult for them to understand the details of the shown production and distribution data. We will research on the kinds of product information they require.

In cooperation with farmers, wholesale markets, carriers, supermarkets and co-ops around Japan, we are continuously planning to perform field experiments of the integrated traceability system on various items of agricultural products. In the experiments, we will improve the system to reduce the cost of RFID utilization, to improve the workability of RFID handling and to get consumers interested in such information disclosure.

Fig. 7. A spinach product with an RFID tag.

Fig. 8. Reading RFID tags which were pasted on container cases in the coop delivery center, using a mobile RFID-reading device.

Fig. 9. A web application for information disclosure on the spinach products. This display shows a list of time-series records on a product's distribution process.

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