A Real Time Food Auto Traceable Authentication System

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Abstract

The current traceability system certifies traceability accuracy by on-site examination or sampling inspection to promote food safety. However, such an afterward test and trace model no longer guarantees food safety. The food safety scandals that happened in the past few years called into question the effectiveness of the entire examination system. An instantaneous tracking and tracing system will significantly lower the usage of substandard products and low-price substitutes at the marketing stage and prevent dishonest conduct in traceability-related businesses. This study designed a new tracking system incorporating logistic codes and tracking codes to enhance the current agricultural produce's security mechanism and the food traceability certification system. This mechanism adopts the virtual correlation model to reduce certification costs. It provides a complete and sound real-time tracking system for society and the industry to safeguard consumer rights and promote the competitiveness of qualified businesses.

Keywords: Food Traceability System; NFC; QR Code; RFID; Traceability System

1 Introduction

Agricultural produce traceability certification management aims to enhance the quality and safety of processing products and promote people's health and consumer rights. Traceability is defined as the complete records of open and traceable agricultural produce from production, processing, package, distribution to sales, and the labeling are qualified by the certification authority. The distribution process is the transaction affecting the integrity of agricultural products, such as the original package or labeling of agricultural produce, organic agricultural produce, or agricultural processing products. Therefore, complete records could offer correct tracking and tracing for traceability [8].

The agriculture and food traceability system informs consumers about their diet [22, 23]. A consumer can input the "tracking number" of a product certified by the certification authority to acquire information on product areas, producers, production processes (including the use of chemicals and the examination results of Good Agricultural Practice, GAP), output, packaging, and delivering [20]. In this case, the damage coverage and the responsibility belonging can be clarified at the first moment when food safety events occur. It is necessary to manage the tracing source, examine at all levels according to the product removal, recovery, and compensation processes, prevent the events from spreading, and guarantee food safety for consumers [20].

To effectively manage traceability, tracking and tracing, supply, delivery, distribution, and sales information should be thoroughly controlled [9]. Therefore, the traceability system is called Traceability Information, which is eventually achieved by transforming barcode labels into information flow [28]. In addition, the agricultural produce traceability certification management should be satisfied the following "information openness and preservation" and "labeling" requirements:

1) The authority should certify Public information in the information system.

2) Product labeling should cover (1) the label, (2) the name of the product, (3) the trace code, and (4) the way of information openness.

3) The traced, inquired, and open traceability information through the information system should at least contain (1) the name of the product, (2) the name of the agricultural produce businesses, (3) the place of

production, (4) trace code, (5) major event in operation, (6) date of the package, (7) name of certification authority, and (8) validity of the certification.

In short, when any parts of the product label are changed, the changed information needs to be transmitted [5, 12, 19]. The premise is to master all transparent information in and out of the marketing spots. However, it is considered as static records; in fact, the dynamic delivery process is often ignored as it is defined as not changing the label information and no need for printing labels. Therefore, it results in the blind spot of traceability. Accordingly, an accurate automatic traceable tracking and tracing system cannot be established because the tracking and tracing cannot be in active condition. Applying the concept of traceability route to this study, the product delivery at the logistics stage is also included in the tracking and tracing to establish an automatic traceability system [4]. By reinforcing real-time monitoring, it could develop the effectiveness of finding and dealing with problems at the first moment [7].

The successive sections are organized in the following. The tracking and tracing model [11] and the deficiency of the current traceability system are described in Section 2. Section 3 demonstrates the automatic tracking and tracing system model proposed in this study; the tracking and tracing mechanism and the advantages of applying logistics virtual codes are also explained. The differences between the current system and the one in this study are analyzed and compared in Section 4. Finally, conclusions are proposed in Section 5.

2 Tracking and Tracing Model and Deficiency of Current Traceability System

This section explains the tracking and tracing model, coding, and the current traceability system's deficiency.

2.1 Tracking and Tracing Model of Current Traceability System

In the tracking and tracing model of the current traceability system, the information of producers, wholesalers, processing manufacturers, and retailers are transparent, allowing the authorities and the certification authorities to track the product flow and relevant businesses and consumers to trace the product flow. In this case, the tracking and tracing objectives could be achieved with complete records [13]. As a result, tracking products with materials needs to forecast the product flow, and tracing materials from products could check the current source [24]. Finally, a consumer can confirm and prove the product security in the system with the "trace code" on the label. A "trace code" similar to the identity of agricultural produce plays an irreplaceable information flow in the system [9]. The following section will explain how the coding of a "trace code" records the regulated open information and how the system creates a win-win for producers, distributors, consumers, and managers.

2.2 Coding of Trace Code

According to the 2004 coding standards, the trace code was designed based on the structure of the 14-digit traceability trace code (TC) in Table 1 and extended to the distribution code (DC) and electronic distribution code (EC) in Table 2. Furthermore, to cope with the one-print-one-trace code policy of the Agriculture and Food Agency and to complement the inadequacy of the original trace code NNNN, the design is reinforced as an electronic distribution code (EC) in Table 3.

Consistent data exchange standards are used for outputting the column definition and various standards to achieve the food tracking and tracing objectives and complete the food production information system [6, 21, 27]. The product could be upward traced or downward tracked from the shift at stages to label necessary information on the batch of food [14]. Meanwhile, the safety of supply chains can be controlled through production management, logistics process, liability assessment, and risk articulation [14].

2.3 Deficiency of Current Traceability System Coding Model

The food tracking and tracing application management [1, 2,10,21] loads the product information to the tracking and tracing system (Table 4). In addition, it plans a complete food cloud core structure to integrate upstream and downstream businesses in the food industry. Furthermore, it advises businesses on developing the food tracing information system, which expects to expose the flow of problematic products, allow the co-supervision of consumers, and guard the national health and welfare [20].

In Table 4, the overlapped management items in the product differentiation are the critical tracking and tracing information in the system [19]. Nevertheless, because of the shift in product differentiation, it is considered insufficient to master logistics businesses [15].

It is evident that the Delivery barcode in Step 2 conveys the Material barcode in Step 1, and the Delivery barcode in Step 8 conveys the Certification barcode in Step 7 [9]. According to the description in the previous section, the distribution code or the electronic distribution record number in the delivery barcode is the same no matter which logistics delivers the product [21]. The system does not identify or certify it because the logistics delivery process is regarded as internal auditing and tracking [3]. For this reason, a person could duplicate the delivery barcode, and the abnormal situation of two products with one code in the allowed time might appear to result in a loophole. On the other hand, the trace code is updated merely when the content is changed. Therefore, the distribution barcode at the logistics stage will

Table 1: Design of traceability trace code

Format	D	○○○○○	YY	BB	NNNN
Meaning	Category code	Organization code	Year code	Phase code	Serial code
Description	1-2 Agricultural produce 3 Ornamental flower 4 Aquatic product 5 Poultry product 6 Pig 7 Other livestock product 8 (Processing food) 9 (Reserved) 0 Circulation code use	Serial number in TAFT database for production units or manufacturers	20YY	1. Use for mixed product delivery, BB = 00 2. Standing for the BB phase production in the year 3. Use for inadequate digit of serial numbers	Serial number of the batch production given by the information system

Table 2: Design of distribution code

Format	0	0	D	○○○○○	Y	NNNNN
Meaning	Category code			Organization code	Year code	Serial code
Description	Distribution code	Processing code	1-2 Agricultural produce 3 Ornamental flower 4 Aquatic product 5 Poultry product 6 Pig 7 Other livestock product 8 (Processing food) 9 (Reserved) 0 (Reserved)	Serial numbers of production units or manufacturers in TAFT database	200Y	Serial number of the batch production given by the information system

Table 3: Design of electronic distribution code

Format	0	2	D	○○○○○	Y	NNNNN
Meaning	Category code			Organization code	Year code	Serial code
Description	Distribution code	Electronic distribution record number	1-2 Agricultural produce 3 Ornamental flower 4 Aquatic product 5 Poultry product 6 Pig 7 Other livestock product 8 (Processing food) 9 (Reserved) 0 (Reserved)	Serial numbers of production units or manufacturers in TAFT database	200Y	Serial number of the batch production given by the information system

Table 4: Regulations of Food Tracking and Tracing System Management

Number of article			Article 4	Article 5	Article 6
Product differentiation			Manufacturing, processing, formulating	Input	Sales, output
Type of information	Order	Management item			
Supplier	1	Basic information of a business or a company name	✔	✔	✔
	2	Name of product	✔	✔	✔
	3	Net weight, volume, quantity, or measurement	✔	✔	✔
	4	Batch number	✔	✔	✔
	5	Expired date or production date	✔	✔	✔
	6	Date of receiving	✔	✔	✔
	7	Information of raw materials and place (origin) of production	✔	✔	✔
Product flow	1	Basic information of logistics businesses and downstream manufacturers	✔	✔	✔
	2	Name of product	✔	✔	✔
	3	Net weight, volume, quantity, or measurement	✔	✔	✔
	4	Batch number	✔	✔	✔
	5	Expired date or production date	✔	✔	✔
	6	Date of delivery	✔	✔	✔

not need to update the code. In this case, a person will have enough time for fraud to cause a blind spot in tracking and tracing [9]. This is the problem and blind spot this study intends to solve. An automatic tracking and tracing management mechanism combined with the current system is proposed in this study to overcome such blind spots and problems.

3 Automatic Tracking and Tracing Traceability System

An automatic real-time traceable certification tracking and tracing system is named in this study [4]. The system is aware of the product location anytime once the first barcode label is output to the sales and a consumer [2]. Under the safety premise of repetition as fraud, the system immediately alerts any repeated labels to guarantee the management. Furthermore, the traceability route and logistics virtual codes are classified for reinforcing physical codes' tracking and tracing mechanism [4].

3.1 Traceability Tracking and Tracing Mechanism

For a system, the upward tracing-and-inquiring and the downward tracking-and-monitoring are technically both sides when the loaded information is adequate [7]. Besides, abnormity will be tracked so that unpreventable abnormal events can be traced to the sources to explore the causes [14]. For this reason, the operation model for the tracking and tracing mechanism is set before proposing the automatic traceable tracking and tracing system in this study, shown in Figure 1, to construct the proposed traceability [11]. First, the tracking and tracing routes are executed through the system association diagram.

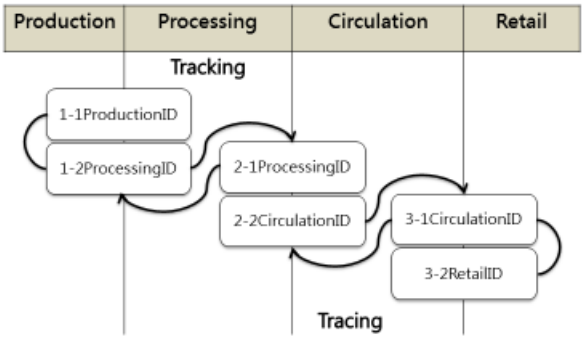

Figure 1: Traceable tracking and tracing multi-level association mechanisms

In Figure 1, at least three association diagrams, (1-1.1-2), (2-1.2-2), and (3-1.3-2), are required for the four traceability stages. For example, the tracking route shows 1-1 production ID→1-2 processing ID→2-1 processing ID→2-2 distribution ID→3-1 distribution ID→3-2 sales ID, and the tracing route reveals the reverse 3-2 sales ID→3-1 dis-

tribution ID→2-2 distribution ID→2-1 processing ID→1-2 processing ID→1-1 production ID. As long as the parts are linked, the required traceability information can be immediately inquired with a product trace code (ID). Under such a mechanism, logistics (ID) virtual codes could reinforce the tracking and tracing mechanism of physical codes [18], allowing products to be tracked and traced anytime.

3.2 Logistics Virtual Code Information Flow Tracking and Tracing Mechanism

In the food and relative product tracking and tracing system, the product flow is regarded as the primary information, stressing "forecasting" the product flow [17] (logistics businesses and downstream manufacturers). This study aims to reinforce the tracking and tracing mechanism of physical codes that should still be followed. To achieve strict tracking and tracing and externalize internal auditing information at the logistics stage, the added trace code is called a "logistics virtual code." Figure 2 shows the logistics virtual code information flow tracking and tracing mechanism proposed in this study.

The delivery process in the logistics business is included in the internal auditing process in current traceability. Concerning the current development of supply chain tracking technology in logistics businesses, it looks reliable to link an external tracing mechanism with the internal tracking system [24–26] when abnormal events occur. However, fraud in the delivery process or the abnormal certification at the delivery destination cannot timely make up for the deficiency. Accordingly, this study proposes combining delivery receipts of a logistics business with the tracking system in a certification center to avoid the risk in the product delivery process. Before a logistics business delivers the product, the product flow has to be accounted for according to the regulations. The traceability is scanned or sensed with a mobile device at the delivery stage for real-time uploading to the traceability certification center and to record individual product traceability, product flow, and mobile device ID. This is the logistics ID, as shown in Figure 2.

Under the structure, the connection of logistics codes, and traceability, it could achieve the advantages of externalization, virtualization, and automation.

3.2.1 Externalization

Because of the boom of logistics supply chains matching with relatively automated logistics devices, the product flow delivered from the logistics to the destination is the standard logistics tracking process of internal auditing in a logistics business [15]. As a result, a logistics business could offer real-time product inquiry services for clients. The processes of making orders, delivery, arrival, and inspection of goods could be achieved through internal tracking. The current traceability system also regards the operation as an external supporting system, but merely auditing risks with sampling inspection and examination [21]. From 1-3 and 2-3, Logistics ID designed at the processing and distribution stages in Figure 2, a logistics business could advise the flow location of an individual product at a time point in the channel. Consequently, it results from externalizing internal operations in a logistics business. When internalizing it in the traceability process is the deserved service of the consumers of a logistics business, the traceability certification unit could understand any product flow with such a design, and the change of externalizing the logistics process to the traceability internalization will have the system integration to develop the effectiveness of complete monitoring.

3.2.2 Virtualization

It is assumed that this designed mechanism is operated under the original traceability coding to promote the system with minimal changes at various stages. Furthermore, under the premise of the traceability code not being updated when the traceability content is changed, the combined logistics ID is regarded as a virtual code for the system's regular operation. From the mechanism in Figure 2, the tracing route does not contain the combined logistics ID. In other words, a logistics ID merely appears in the tracking route and is disposed of after use. Once the product arrives at the designated product flow location, the system will automatically delete the tracking association and recover the association with the original system. Since the logistics ID is not listed in the traceability code, the issuing party does not need to print the logistics ID. Therefore, It presents a virtual state, assists the system in the tracking ability, and applies the current advantages of logistics businesses to enhance the integrity of traceability systems.

3.2.3 Automation

As the above descriptions of externalization and virtualization, this study can be further applied and developed after integrating traceability with the system of a logistics business [15]. For example, the certification center could assign the product flow party and inquire about the product in the traceability tracking and tracing system after receiving the product flow and the logistics ID uploaded by the logistics business. Two auditing points could be mastered in the process; one is the logistics delivery device, and another is the stock system at the product flow end. When the traceability code is scanned or sensed at the first auditing point, the system synchronously starts 1-3 or 2-3 Association in Figure 2 Logistics ID, automatically transmits the logistics ID and the product traceability information of the seller to the buyer, as well as strictly monitors the period for product delivery according to the regulated delivery time management items. When the second auditing point receives the product, the stock system would immediately uploads the product traceabil-

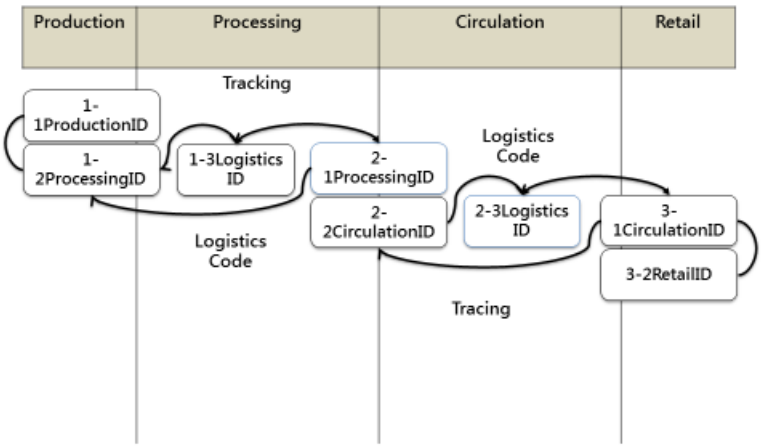

Figure 2: Logistics virtual code information flow tracking and tracing mechanisms

ity to the certification center after scanning or sensing the product traceability to remove the virtual state of a logistics ID. The certification center would calculate the delivery time for standard delivery to the product flow end. If not, the system would immediately trigger the alert message for purposive examination. In this case, the automation process could delete any abnormities induced at the stage to perfect the traceability system and achieve preventive effectiveness.

In sum, the combination of the tracking and tracing mechanism of logistics characteristics proposed in this study presents the advantages of externalization, virtualization, and automation. The system properties are further analyzed and compared to understand the contribution of this study to the current traceability tracking and tracing mechanism.

4 Analysis and Comparison

The comparison between this system model and the current traceability system is demonstrated in Table 5.

4.1 Traceability Coding

A trace code is defined as the code to identify the traceability of agricultural produce of different batches. The design in this study follows the original traceability coding and structures on the original system. However, it is still compatible with another self-designed coding, presenting more excellent expandability by accepting tiny system changes and being compatible with other heterogeneous systems.

4.2 Information Flow Association

As the comparison between Figure 1 and Figure 2, the information flow of the current system shows 1-1 production ID←→1-2 processing ID←→2-1 processing ID←→2-2 distribution ID←→3-1 distribution ID←→3-2 sales ID, where ←→ stands for the tracking route and the tracing route being the same but opposite. The system's information flow in this study divides the tracking and tracing routes into two different routes. The tracing route is consistent with the current system as 3-2 sales ID→3-1 distribution ID→2-2 distribution ID→2-1 processing ID→1-2 processing ID→1-1 production ID, while the tracking route is added the logistics time flow as 1-1 production ID→1-2 processing ID→(1-3logisticsID)→2-1 processing ID→2-2 distribution ID→(2-3logisticsID)→3-1 distribution ID→3-2 sales ID. The tracking route is still the same as the current system after completing the logistics delivery and inspection of goods.

4.3 System Integration

In the era when Cloud is prevalent, internal auditing depends on the operation of a private Cloud, while external auditing relies on constructing a public Cloud. When a producer cannot construct a private Cloud, it is requested by the authority to register relevant production information with excellent agricultural produce certification management and regarding farmers as the internal customers [2]. Therefore, the information at this certification stage could be the indirect internal auditing management measure to construct further the basis of the tracking and tracing traceability system, similar to sharing private Cloud on public Cloud. The logistics virtual code information flow tracking and tracing mechanism designed in this study attempts to externalize the information in the internal auditing private cloud at the logistics stage and includes the traceability in the public Cloud. By applying logistics tracking advantages, it reinforces the tracking and tracing channels of the original system through system integration. As a result, a more efficient tracking and tracing traceability system will be naturally constructed when matching with the relevant law amendment.

Table 5: Comparison between this system and current traceability tracking and tracing mechanism

Differentiation Differentiation	Current tracking and tracing mechanism	Tracking and tracing mechanism in this study
Traceability coding	According to regulations	Following and compatible with current regulations
Information flow association	Traceability stage	Traceability stage and logistics information
System integration	Original traceability system	Combining with the deliver in logistics system
Logistics device ID	Not included	Including virtual code
Automation	Yes	No
Dynamic tracking	No	Yes
Tracking schedule	Discontinuous	Fully
Real-time certification ability	No	Yes
Certification cost	High	Low

4.4 Logistics Device ID

Logistics devices generally can scan or sense barcodes and aim to control the logistics delivery process timely. However, since the current system focuses on distribution information to master the retail and wholesale of products, the logistics device ID has not been included in the tracking and tracing mechanism. This study's design emphasizes complementing the monitoring during the product delivery to block someone from duplicating the traceability barcode. For this reason, logistics' delivery, distribution, and transit storage information is included in the tracking and tracing. Furthermore, the virtual code association, automatically deleted when the product arrives at the assigned product flow location, is applied to densely connect the data. Therefore, the advantages of logistics supply chains could be applied to current traceability for success.

4.5 Automation

As the current system focuses on distribution, the tracking will eventually be entrusted to the internal auditing of logistics which can hardly achieve the efficiency of automation. Therefore, logistics tracking is introduced in this design. Section 3.2.3 mentions that two auditing points derived in the process are utilized for directly uploading the movement of the certification center through current logistics devices and the scanned and sensed traceability of stock to achieve the efficiency of automation.

4.6 Dynamic Tracking

The upstream and downstream relation of the tracking traceability in the current system is undoubted. Regarding the current system, there are correspondent recording standards for production, processing, and distribution for system tracking. However, they are point tracking, after all. Therefore, the shifting information between points at each stage is still not included in the system information flow. Therefore, dynamic tracking can hardly be operated. Besides, the start of tracking is merely established on an artificial examination, so it could not satisfy the initiative. Nonetheless, the technique introduced to the design in this study is based on dynamic tracking, so the certification unit could immediately construct complete tracking information when receiving the logistics code and the product traceability label, making the certification mechanism automatically compared with the product flow and the delivery time to acquire the dynamic tracking effect.

4.7 Tracking Schedule

The product flow schedule is often changed because of delivery locations. When a speculator delivers an imitation (the real one is purposively delayed), it takes 8 hours for the repetition collision (the arrival), as the situation in Taiwan. As the delivery at the logistics stage is interrupted, the current system cannot inquire about the collision during the delivery, and it has to wait until the sales stage. Therefore, the tracking time is comparatively more extended than the design in this study; particularly, the logistics code is compared with the product flow information and the delivery time in this study, so the delivery problem with an imitation could be blocked. Consequently, when purchasing in a correspondent certification department, a consumer can reduce the risk in food safety to zero. It is thanks to the design of seamless tracking time.

4.8 Real-time Certification Ability

The so-called real-time certification refers to the ability to inspect illegal traceability products in real-time. The current system focuses on the change of product content to decide the update of the traceability barcode [16]. Therefore, the certification works depending on the sampling inspection result. Even though a problematic product is inspected, it can hardly reconstruct consumers' confidence once the damage occurs. Therefore, the importance of real-time certification for the system is apparent. The

design in this study especially takes the product certification at the delivery stage into account to make up for the deficiency of the current system. The product collision or irrational delivery time could be discovered and handled with the assistance of logistics virtual codes to complement and improve the current system, and it is a design system with high practicability.

4.9 Certification Cost

The certification cost of the current system is based on the workforce, and the certification performance requires a sufficient organizational system. It is considered outdated in the current food cloud era [28]. This design externalizes the internal delivery in the private logistics cloud to the internal parts of traceability with an automated tracking system equipment in the current logistics system. The certification unit merely needs to certify the devices of a logistics business. It is included in the tracking mechanism to obtain timely, dynamic, and time-reducing effectiveness, reducing the certification cost and dramatically enhancing the certification performance. This design could reduce the authority's certification cost by promoting the traceability 2.0 policy.

5 Conclusion

To overcome the blind spot and problem in certification management during food delivery, the automatic traceable system proposed in this study covers the internal auditing of logistics delivery in the traceable internal auditing tracking mechanism. It applies the virtual association model to delete it after the product completes the assigned product flow and is thoroughly examined. Therefore, it could complement the current system's deficiency and enhance the system's real-time tracking and certification functions. From the analysis and comparison, the logistics device ID is included in this study through the system integration with logistics information without changing the original traceable coding structure. Therefore, it presents the efficacy of automation, dynamic tracking, and reduction of tracking schedules compared to the current system. Besides, the unique real-time certification ability essentially reduces the certification cost that presents high practicability. Therefore, this design is expected to assist the authority in promoting the traceability 2.0 policy, meeting the new traceability era, maintaining food safety, reconstructing consumer confidence, and enhancing the competitiveness of quality businesses.

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Biography

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