DEVELOPMENT OF AN ICT-BASED TRACEABILITY SYSTEM IN COMPOUND FEED INDUSTRY

Zeynel Cebeci[1], Yoldas Erdogan[2], Tuna Alemdar[3], Ladine Celik[4], Mustafa Boga[4], Yusuf Uzun[4], H. Durdu Coban[1], Murat Gorgulu[4], Funda Tosten[1]

1) Div. of Biometry & Genetics, Fac. of Agriculture, Cukurova University, Adana, Turkey

2) Dept. of Informatics, Cukurova University, Adana, Turkey

3) Dept. of Agricultural Economics, Fac. of Agriculture, Cukurova University, Adana, Turkey

4) Div. of Feeds & Anim. Nutrition, Fac. of Agriculture, Cukurova University, Adana, Turkey

ABSTRACT

The term traceability refers to recording of movements of products along the food chain from production to consumption. This includes all intermediate applications involved in processing and combining inputs into new products throughout the supply chain. The aim for establishing traceability in the food chain is to provide the timely identification and removal of any batches of product from the market when a risk threatens the health of consumers. Since compound feed products are basic inputs in livestock and poultry production, ICT-based feed traceability systems should be established to realize an efficient initial step in food traceability management. Feed traceability systems are simply information recording systems that are designed to trace and track the flow of animal feed and their characteristics along the feed supply chain. This paper describes the architecture and some functional properties of a feed traceability system named as the “feedTRace”, focusing particularly on compound feed and integrated poultry meat industries. The feedTRace aims to improve compound feed supply chain management, to increase feed safety and quality control, and to gain marketing competencies with traceable products in compound feed industry. The system is currently under beta stage, and is tested in two high capacity feed factories and an integrated broiler company located in Adana province of Turkey.

Keywords: *compound feeds, feed traceability, traceability systems, food safety*

1. INTRODUCTION

In the last 3 decades, many food hazards have been outbreak due to several biological agents such as the zoonoses infections (HIV, SARS, AI, vCJD, West Nile, streptococcus, salmonella etc.) in addition to physical and chemical residues and contamination in various stages of agricultural production, food processing and transporting. These food-borne health risks and problems have revealed the need for food safety related regulations that should be enforced to protect public health and to increase the trust of consumers. The demand and expectations for safe and high quality food have directed governments to take some action measures and issue some regulations to ensure food safety and security (CEBECI *ET AL.*, 2008).

Probably the first of food safety regulations in the world has been enacted by European Commission (EC), which is titled the European Union Food Safety Law, and numbered EC 178/2002 (EC, 2002). In the United States, the Congress responded by passing the “Public Health Security and Bioterrorism Preparedness and Response Act of 2002 (also known as the Bioterrorism Act shortly) (US CONGRESS, 2002). Like EU and US, many other countries have also published laws regulating food safety. For instance, Japanese Government enacted Food Safety Basic Law in May, 2003 (YOKOYAMA, 2007), and the Law of Traceability for Agricultural Products was put into operation in August, 2005 in Korea (SEO & LEE, 2007). Turkey also has ensured food safety by enforcing Law 5179, titled as "Law of adoption of the amended decree by-law on the production, consumption and inspection of foods" in 2004 (TBMM, 2004).

Since traceability is defined as the ability to follow a feed or food through specified stage(s) of production, processing and distribution (ISO, 2007) the term traceability refers to recording of movements of products along the food chain from production to consumption. It also includes data from all intermediate applications involved in processing and combining inputs into new products throughout the supply chain. Therefore, traceability can be considered as a tool in food safety**,** which aims for establishing systems to provide the timely identification and removal of any batches of product from the market when it threatens consumers' health.

Even though traceability is decreed by the governments**,** the regulations do not outline the methods and techniques to meet the rules for traceability. So there is a strong need for standards, guides and/or best practices in order to apply traceability in food supply chain, properly. Although, there are currently 413 different international standards on several aspects of food safety, a few of them also cover traceability requirements (KHO, 2008). The standards such as Codex Alimentarius, ISO 22000:2005, ISO 22005:2007, GLOBALGAP, British Retail Consortium (BRC), Global Food Standard, Safe Quality Food (SQF) 1000 & 2000 and CIES Global Food Safety Initiative defines the traceability and traceability requirements in some levels. Among the others, ISO 22005:2007 is the latest in a series of food safety standards launched in 2005 by International Standards Organization (ISO, 2007). The new standard of ISO titled "Traceability in the feed and food chain" establishes the principles and requirements for the design and implementation of a feed and food traceability system. It offers a solution for good practice on a worldwide basis and thus contributes to lowering trade barriers.

Food traceability systems record the flow of food products or ingredients in food products from its initial supplier through all processing stages until they reach the consumers. Similarly a feed traceability system can simply be considered as a subsystem of an animal-originated food traceability system. Feed traceability systems are designed to trace and track the flow of animal feed and their characteristics along any feed supply chain. Safe feed for animals is an absolute requirement for the food chain. Feed traceability systems facilitate to document and track any batch of a product through the stages and operations involved in the production, processing, distribution and handling of feed, from primary production to consumption. They can therefore enable the identification of the cause for any hazard with products, and the ability to recall them if necessary.

Although, today, many food traceability systems are already in place around the world**,** there are a limited number of projects which are specific to feed traceability. One of the projects on feed traceability has been realized by Product Board Animal Feed of the Netherlands in 2002 (PDV, 2002). It outlines the structure and principles of traceability in feed chain. Considering ISO and PDV approaches and standard on feed traceability, this paper describes the architecture and some functional properties of the "feedTRace", a feed traceability system which is focusing particularly on compound feed and integrated poultry industries. The feedTRace aims to improve compound feed supply chain management, to increase feed safety and quality control, and to gain marketing competencies with traceable products in compound feed industry.

2. SYSTEM ARCHITECTURE AND FUNCTIONAL ASPECTS OF FEEDTRACE

2.1. Design principles of feedTRace

In general, the food safety regulations decree all businesses in the food supply chains must implement traceability with one-up and one-down basis. Although this kind of traceability approach is enough for finding the origin of any problematic food it may not efficiently work for ensuring consumer protection in a desired level because it has some intrinsic inadequacies. At first, farmers, processors, distributors and other businesses in the chain apply various solutions from very simple paper-based filing systems to ICT-based traceability systems in different complexity levels in order to meet traceability requirement. Secondly, vertical and horizontal data exchange between businesses through the chains is very difficult for some reasons. Aside from using paper-based traceability, many of existing ICT-base systems also cannot perform data exchange between them. Consequently, data recording and information flow become scattered and too costly with one-up/one-down traceability applications. Moreover, tracing of the product to its origin and then recalling cannot be realized in a short time in any emergency case due to the factors mentioned above.

As stated in the ISO 22005:2007 standard, a traceability scheme would allow organizations operating at any step of the food chain to (1) *trace the flow of materials, including feed, food, their ingredients and packaging;* (2) *identify necessary documentation and tracking for each stage of production*; (3) *ensure adequate coordination between the different actors involved*, and (4) *require that each party be informed of at least his direct suppliers and clients*, and more (ISO, 2007). The approaches listed above points to establish traceability systems that can ease and quicken data recording from one business to other. The goals listed above can be achieved by several ways:

- All businesses can use a central traceability system and/or central database,
- Even if their systems are unconnected**,** a data exchange mechanism can be applied between them.

It is obvious that a network infrastructure and connectivity is needed for both cases mentioned above. Quantitative and qualitative measures on type and level of connectivity differ between the countries, regions and also for communities in the food chain. For instance, since the availability of xDSL internet connection is limited in rural areas, web-only applications will not work for rural communities, efficiently. On the other hand mobile phones are widely used as communication devices for the farmers living in rural areas in most of the developing and less developed countries SMS like mobile services would be successful for the farmers to participate to ICT-based traceability systems. Beside technical properties of traceability system there are more constrains on organizational, financial and socio-cultural aspects that should be taken into consideration in the design and architecture of a traceability system. Some of them are governmental support, organizational culture, administrative maturity, informatization/computerization, staff skill, staff cost, and government online presence and services (GRÖNLUND *ET AL.*, 2005).

Today, within "farm to fork" traceability, it is a fact that they are mostly not visible to consumers as the owner of forks, at the point of sales. Whilst a traceability system is accessed by consumers food safety could be more ensured and improved. If the consumers can query barcode number labeled on packs in markets they may more safely choose their foods during shopping. Online tracing of products by consumers will help for choosing foods on their geographic origin and applied processes along the chain. In this way, querying on the traceability system will involve the consumers in system to control and improve safety mechanism, and also to increase consumer trust.

As a final conclusion, quick identification and recalling a commodity of problematic food and its ingredient sources from the chain is very crucial to ensure recall and prevent/reduce the hazard to public health. For this aim, the ability of trace and track querying and reporting components in a traceability system is important for managing tracing and recall procedures and processes.

In the design of feedTRace a networked, multi-interfaced (web, sms, i-kiosk), multilingual and interoperable traceability system was aimed in order to meet the issues mentioned above.

2.2. General architecture of the feedTRace traceability system

As it can be seen from Figure 1, feedTRace system has been designed as a system having three-tier architecture: client, application and data tiers.

Access in client tier was aimed to be established through cellular phones, PDA devices, and Internet kiosks in addition to traditional computer systems.

Application tier of feedTRace is composed of the following components:

- Registry data and organizational management
- Membership and session management
- Transactions and internal applications management
- Traceability (trace and track) reporting and management
- Communication and messaging management
- Data exchange management
- System administration

Registry data and organizational management consists of software components which ensure recording and updating data including system users and roles, inputs, businesses and types of businesses, applications and treatments realized in production process in businesses, finished and semi-finished products (outputs), and geographical data. The procedures in this component could be employed by users having “administrative” status and those roles are assigned by the feedTRace system administration. Main objective of administrative procedures is forming records which ensure rapid and uniform entry of procedures such as input, output transactions and transportation, as well as carrying out recording activities of farms and users within those farms who are using the system.

In other words, all likely inputs to be used, all likely processes and applications to be performed, and all likely types of products to be produced within every node of chain enterprises are recorded to the relevant database of the administrative procedures as internal procedures applied in any place of production. In this way, user of a business can rapidly enter all his/her daily processes in the production place through user processes section by selecting related item from the pop-up menu instead of rewriting them in new-process-application entry section. Hence, standard and uniform data entry is ensured through recording main input, output process and applications by registering them to the database.

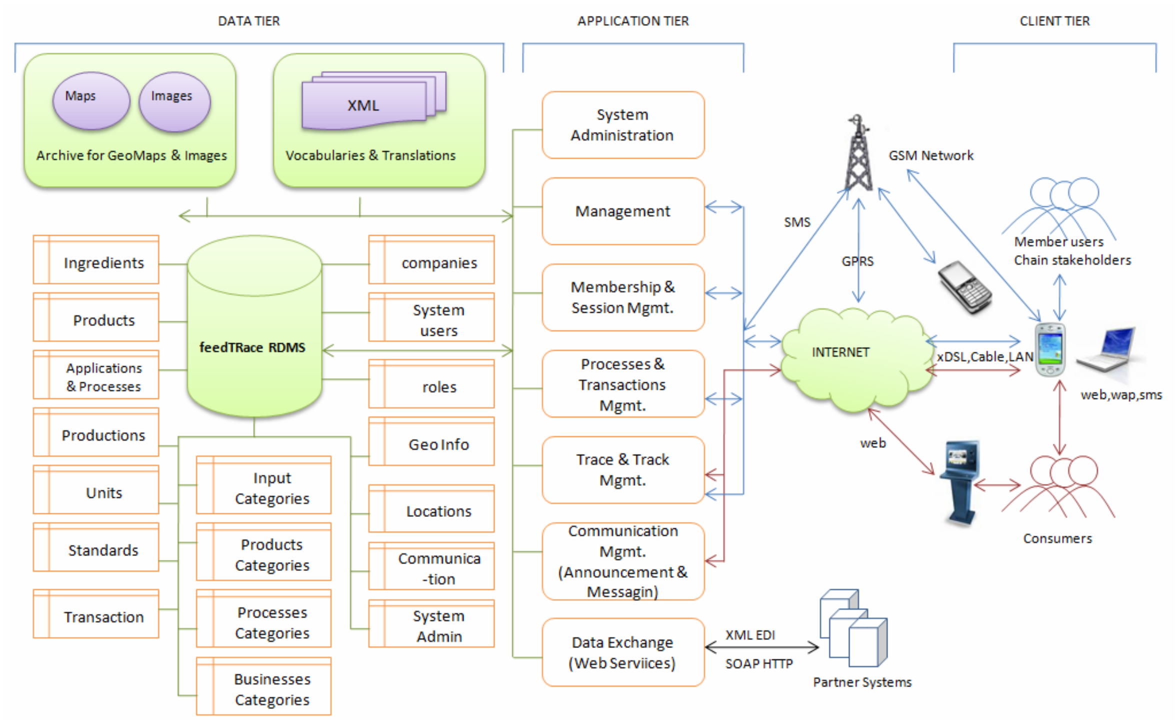

Figure 1. General architecture of the feedTRace traceability system

Membership and session management components are those components which supervise log on and authorization levels of the system users and ensure management of the started sessions. These components carry out system log on and log out activities. Security applications could be enabled on users' log on-log out times, system IPs and authorization levels as soon as they log on the system.

Management of inputs, production, process application and output movements is a central component of the feedTRace system and this component provides management of records subject to traceability. Transactions and internal applications component of the system consists of three subcomponents:

- Input processes: Recording, updating and listing of production related purchases of an enterprise, such as cereals, seed, seedling, nursery, pesticide and medical stuff, fertilizers, feeds, and chicks.
- Production processes: Recording, updating and listing of any production activity in an enterprise (for example: wheat, broiler feed production etc.)
- Output processes: Recording, updating and listing of products produced at the enterprises (for example: wheat, feed, milk, broiler etc.)

feedTRace produces a unique production code for each production activity and inputs, treatments and applications performed are all related to the relevant production process through this code. In this way, inputs, outputs, processes and applications of any production activity can be easily determined.

Another service provided by the feedTRace system is that an input purchasing company which buys an input from another firm can see the name of this item in the list of inputs waiting for approval and can change the status into input records just by approving the purchase. In this way, no reentry is required for input definition data during input transactions and also speed and convenience are provided for enterprises having intensive input transactions.

Traceability management component of feedTRace covers software components providing determination and reporting facilities for process and applications which a product is subjected to, locations which a product is produced, distributed and transported through. When any problem occurs related to a product, all required measures can be taken including roll back since source of problem is identified through backward tracing and locations where the product is distributed to is determined through forward tracing. Traceability activity, which is one of the major functions of a traceability system, can also enable a traceability which takes into consideration consumer preferences in addition to problem identification and enabling recall procedures. Consumers can also access to relevant production and process data by entering traceability codes written on the product packages at Internet connected kiosks located at places where the end products are sold. This search will be accomplished through traceability barcode reading systems integrated into the Internet kiosks and automatically searching related codes in feedTRace database. Participation of consumers into the system with this kind of technologies at sales point will provide transparency and meet ideal expectations regarding food safety to keep consumers' trust.

Communication management section of feedTRace consists of applications handling**,** generating and mailing of monthly newsletters, traceability reports as well as sending announcements and messages from system administration to the system users and vice versa.

Data exchange between institutional traceability systems and/or ERP systems becomes very important in food supply chains. In sector specific traceability systems such as feedTRace, when products are transferred to the network of any other sector, it becomes very important that all product-related data should also be transferred (exported) to the traceability system or the institutional information system of the network where the product transferred. The same also applies for the products entering into feedTRace system from other channels and also particularly for inputs coming from input suppliers. For this reason, data exchange applications were developed to manage data import and export processes for the feedTRace database.

System administration within the application tier covers applications ensuring technical and administrative management of feedTRace itself. This component provides services such as error reporting, usage statistics, backing up databases, analysis of system performance.

Data tier of feedTRace is the back end tier that stores registry data, transactions and production records**.** System database consists of tables for users, enterprises, transactions (inputs, outputs, processes and applications) as seen in Figure 1. In addition to central database management system in data tier, a directory system for images and maps is also allocated for storing aerial maps, satellite maps and photographic views of the registered farms and other enterprises. These images and maps are used both by users for forming consumer preferences at barcode based viewing systems located at Internet kiosks and also for rapidly locating farms for recalling when required.

Since products within food supply chain are marketed not only at national level but also on a global scale, feedTRace was developed on architecture with a multilingual interface. Multilingual interfaces allow product traceability to be accomplished on international level and enhance competitiveness of the business. However, present alpha version of the feedTRace has Turkish and English translations; inclusion of files in other languages is as easy as uploading a simple text based XML file to translation space of the system. System automatically detects proper translation interface based on the language of the browser used, and presents the appropriate interface to the user. Additionally, users can also work by selecting any other interface as they like. Adding other language files can be managed very easily, as easy as translating master English language files in the language they wish and then transferring the translated files into "languages" directory.

3. CONCLUSIONS

Today various traceability systems are already in service for establishing safety in the food supply chain. In fact, many food processors had traceability systems for meeting their specific needs including management of recall mechanisms even before food safety regulations came into force. But these systems have been mostly developed as ERP-based systems, and work as standalone applications within the company itself. Since quick tracing of the origin of foods and recalling in a short time are very difficult and costly with this kind of scattered and distributed traceability systems, integrated and full traceability systems will be more efficient. The demand can only responded by using modern ERP systems, which may be able to solve the problems of today's quality food industry problems as stated by HERDON & FÜZESI (2006).

As a matter of fact many countries seize upon regional or country-wide central traceability approaches recently (AAFRD, 2007). For example, Canadian food trade associations (Canadian Council of Grocery Distributors, Food and Consumer Products Manufacturers of Canada and Canadian Federation of Independent Grocers) have joined forces with the Electronic Commerce Council of Canada to try to develop a national traceability standard and system for food products in Canada. Similarly, feedTRace is designed to work in national level to involve all businesses in compound feed sector in Turkey.

Also, when compared with the traceability systems of other sectors such as fresh fruit and vegetables, meat, milk etc., compound feed industry traceability systems faces some specific technical, administrative and financial difficulties. feedTRace is one of the full traceability systems aiming to solve sector specific traceability issues in compound feed industry. These problems are usually originated from the spatial position of the feed sector in food chain. First of all, feed industry is the closest link to the primary producers in the food chain. Therefore, feed industry has to solve data recording problem about grains and other ingredients used as input from the farmers. This is a serious disadvantage for feed industry because most farmers have no enough IT ownership and networked working style for quick data collection. As an efficient solution in data gathering from farmers, thus feedTRace offers mobile interfaces based mobile phone communication in addition to the use of web based interfaces.

With feed traceability there are also some other technical difficulties. One of them is the problem of breakdown of the feed raw materials used as inputs, such as wheat and maize, based on their origins starting with their primary production. Another difficulty is the fact that a great majority of the feed is sold as bulk material without any cover material. The same applies for many countries including European Union. For example: it was reported that 96% of the animal feed produced in the Netherlands is sold in bulk form, 0.3% in big bags and 3.7% in bags. (PDV, 2002). This situation makes it difficult to switch to barcode and RFID based applications, and also prevents users from taking advantages of automation provided by automatic input and output recording systems.

Full separation, breakdown and traceability of grains discharged into the silos are very difficult. For example; feeds discharged into a 50-300 ton capacity silo can mix each other when they are used in production, and ingredients of any produce of them could only be determined through an approximate estimation. This is so, because traceability with a First-In-First-Out (FIFO) technique could not be accomplished. There is a need for switching to separate and small storage systems or for development of some type of electro-mechanical equipment in order to achieve a net traceability. This may be discouraging since it causes a significant amount of investment within the enterprise and R&D investments. At present finding out and using some algorithms giving approximate estimations based on silo structure, type of the raw material and speed of the flow could be recommended.

Above mentioned problems cause some difficulties in integrating barcode and RFID technologies into the traceability systems in compound feed industry. feedTRace system searches for solutions to above mentioned problems specific to the feed industry and tries to enhance and develop system quality elements as a flexible and scalable system. However it is clear that some specific studies are required in this situation.

feedTRace compound feed traceability system which was developed within the context of this study aims at forming a sector-wide pioneer model system. feedTRace also gives an example to a central system formation, with its data structure and flow and design approach combining all stakeholders end-to-end within the supply chain.

There are redundancies causing cost increases in paper based and traditional ERP base traceability systems. Web based feedTRace, covering integrated chain, eliminates these redundancies. Input sales performed by an enterprise are listed as inputs for waiting approval for the purchaser enterprise and can be approved by the purchaser just with a click to check a checkbox indicating approval. Hence, separate recording of a product both in seller and buyer enterprises is eliminated and recording costs are decreased.

Although traceability related legislations stipulates recording for inputs used and products sold in order to use those data in an accidental situation, it takes a great deal of time to determine the source of the problem and recall the products in paper based systems. On the other hand, in ICT-based systems such as feedTRace, finding the origin of a product, determination of the places where it was distributed and warning those places are basic activities carried out almost in real time. Hence recall activities could be accomplished in a short time and threats to health could be minimized. FeedTRace, with its architectural structure covering the whole chain, can provide a full traceability and can report all the history of the products being examined.

In general the user interfaces are web-based in most ICT-based food traceability systems. Although satisfactory for office environments, web based applications are not so for remote rural areas and also field conditions. For example; there might be a need for approaches and designs providing very simple and fast recording facilities in order to record harvests and/or production related processes into the traceability system in the field. In feedTRace system, users would be able to do this by using SMS messages through their mobile phones. Simple and formatted text data sent by a farmer through GSM networks would be analyzed by message analyzing services and transferred to the system database. Another facility provided by feedTRace in this sense is the offline storage of the data recorded in PDAs in the field and in areas without an Internet connection and then transfer of recorded data to the system database through an online connection. So, feedTRace system is a very flexible system since it supports both online and offline working and also takes advantage of using mobile devices in rural areas.

feedTRace system is developed in a way allowing extension of the database records. In this way, additional fields could be added to database tables when required. In addition, feedTRace was designed in such a way that it could be used by international stakeholders thanks to its multilingual interfaces. Today, several protocols do exist for realizing data exchange between the traceability systems. agroXML and Trace-XML in TraceP2P are widely implemented and most promising examples of EDI-XML standards and technologies in the agri-food industry (FÜZESI & HERDON, 2007). Therefore feedTRace system will be powered to import and export traceability data built with these EDI-XML schemas by its own web services on SOAP protocol over HTTP.

We try to realize the following targets with feedTRace: development of a traceability system that can function as a base and sector model; determination of and finding solutions to feed specific problems. Currently, alpha version of the system is being tested in two high capacity feed factories which are operating within the Cukurova region in southern Turkey. The system will be completed within the first half of 2009 and will be populated to cover primary producers (farmers), commissioners (suppliers), and customers (livestock farm), slaughterhouses and processing facilities and lastly the supermarkets. After finalizing the project the plans on sustainability of our system will be carried out by the project team and local associations of growers and processors in the region. Even though "Who will pay?" is still a question which has not been answered enough at present, we plan to apply a sustainable model in the future, which will be co-financed by several companies and supported by the government, based on lots of reports prepared and works carried out up to now. Actually, there is a trend towards being motivated not only governmental regulations but also by economic incentives in developed countries such as US, Canada, Japan and many EU countries. However, it should not be overlooked that governments should support traceability systems in the beginning of transition period in developing countries because of lack of organizational culture and/or inadequate finance of investment and operation of the systems. Thus the feedTrace will be administrated by a jointly founded traceability administration office of the national association of compound feed manufacturers but will demand partial support from the government for some operational costs for some years.

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