Managing Traceability in the Meat Processing Industry: Principles, Guidelines and Technologies

Dimitrios Kafetzopoulos[1], Chrysostomos Stylios[2], Dimitrios Skalkos[3]

[1]Department of Business Administration, University of Macedonia, Thessaloniki, Greece; e-mail: dimkafe@uom.edu.gr
[2]Department of Informatics and Telecommunications, University of Ioannina, Arta, Greece; e-mail: stylios@uoi.gr
[3]Department of Chemistry, University of Ioannina, Ioannina, Greece; e-mail: dskalkos@uoi.gr

Abstract. Food industry is seeking to establish traceability systems and production techniques that may help to promote confidence in the origin of their products. The traceability system is an important tool for controlling and optimizing production, for getting better decisions, and for profiling desirable product characteristics. This study reviews and suggests principles, guidelines and technologies for the traceability of the meat industry. In practice it purposes a framework, that can be followed by companies involved in the meat supply chains in order to make their traceability system more efficient and effective. Concerning principles for a meat traceability system, the unique identification of traceable units, the documentation of transformations and the standardization of information exchange are the most well-established principles. Animals and products identification, database, network, GIS technology and RFID systems are the main traceability technologies for farm animals and their products.

Keywords: Traceability; Meat industry; Animals identification; RFID systems.

1 Introduction

Traceability in the food sector is primarily defined as "the ability to follow the movement of a food through specified stage(s) of production, processing and distribution" (Codex Alimentarius Commission, 2006). The ability to trace the history of a food product, collecting in a rigorously formalized way all the information related to its displacement along the supply chain, is essential for modern companies (Dabbene et al., 2014). Food traceability is a cornerstone of the increasingly complex, industrialized, and global food system. It is useful for clients, producers and manufacturers to track items for supply-chain management purpose (Zhang and Bhatt, 2014). As pointed out by Zhang et al. (2010), an efficient traceability system could support not only information tracking at operational level, but also diagnostic analysis and strategic decision making at managerial level.

In meat supply chains, transparency is necessary to guarantee the safety, quality and trust of consumers in meat products (Kassahun et al., 2014). However, due to the

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increasingly separated production and consumption of meat and the complexity of the supply system, the traditional traceability methods have problems such as lagging management, inefficiency, and lack of means to link the whole process information of the entire meat supply chain (Yiying et al., 2019). The literature review showed that no common understanding of the principles of traceability exists, nor is there a sound common theoretical framework with respect to implementation of food traceability (Karlsen et al., 2013). Moreover, there is a need to present different traceability technologies in animal products identification and to update the methods for information collection and inquiry, to expound traceability policies, guidelines and regulations between countries (Bai et al. 2017).

Thus, the main purpose of this study is to present the common principles and guidelines for traceability in the meat industry, additionally, to present traceability technologies for farm animals and their products. This study is the first that brings together a set of traceability principles, guidelines and technologies, in practice a framework, that can be followed by companies involved in the meat supply chains in order to make their traceability system more effective, overcoming potential disadvantages. The present study contributes to the planning and implementation of traceability systems as a starting point for each meat business to manage its traceability system more effectively.

2 Generic principles for a meat traceability system

Meat traceability usually starts with the birth of the animal, followed by maturing, slaughtering, butchering, processing, distributing, and consumption. Many published studies describing principles of traceability in the food industry, while there are also some well-established principles that underline efficient implementation of traceability in the meat industry (Storøy et al., 2013). These are:

(a) *Unique identification of traceable units:* Moe (1998) points out that traceability is based on unique identification of the products. Unique identification and traceability in any system hinges on the definition of a Traceable Resource Unit (TRU) which is a unique unit. Identifying TRUs and activities is necessary in order to trace a product. TRUs can be described according to weight, volume, etc., and activities can be described according to type and time/duration, such as processing, transportation and storage. Product information can be linked to the identification number of traceable units. Prerequisites for achieving traceability are unique identification of traceable units and records of transformations.

(b) Documentation of transformations: Transformations are points within a supply chain where the resources are mixed, merged, transferred, added or split (Storøy et al., 2013). Transformations are an important factor that affects the potential precision of a traceability system (Bollen et al., 2007; Bollen et al., 2006; Riden and Bollen, 2007). Identifying traceable units and transformation relationships is the key to tracing a product internally and/or in supply chains (Storøy et al., 2013). To be able to trace

backwards to find origin and track forward to find all related units it is crucial to record all transformations.

(c) *Standardization of information exchange:* Another challenge with implementation of supply chain traceability is the exchange of information in a standardized format between various links in the chain. Globalization has led to an increase in the significance of efficient systems for information exchange between food businesses (Storøy et al., 2013).

3 Guidelines for implementation of traceability

Different countries have developed and implemented legal requirements on traceability (Dabbene et al., 2014). Commercial standards for instance, for GS1 standards, GlobalGAP (GlobalGAP, 2013) and British Retail Consortium (BRC) Best Practice Guidelines for Traceability (British Retail Consortium, 2013), present guidelines for traceability implementation. Satisfaction of these commercial standards, which usually corresponds to obtaining a specific certification, represents a necessary condition for a company to access a given market. Traceability guidelines usually focus on 1) product traceability, 2) process traceability, 3) genetic traceability, 4) input traceability, 5) disease and pest traceability and 6) measurement traceability (Opara, 2003).

Moreover, the generic guidelines of traceability include parameter list for the data to be recorded in for all food products (such as: producer ID, trade unit ID, etc.) In addition to the generic guidelines, sector-specific guidelines must be developed which are product specific and includes: (1) Creating a standardized parameter list for the given product throughout the value chain. (2) Identifying data to be recorded at each link in the value chain. (3) Creating a data management and information exchange model for both internal and chain traceability in the value chain (Storøy et al., 2013).

4 Traceability technologies for farm animals and their products

From a technological viewpoint, it can be stated that the devices for identifying and tracing the products have nowadays reached a good level of industrialization, providing new and efficient opportunities for management (Dabbene et al., 2014). A traceability system is a type of information system that is based on the enterprise's creditability (Zhang et al., 2010). In general, a traceability system is composed of the identification of TRUs (Donnelly et al., 2009), a database that provides needful data with TRUs, and information for associating the TRUs with their respective code by collection and inquiry. By TRU and combined the information attributes, the breadth, depth, and precision of traceability system was proposed (Qian et al., 2017).

Animals identification: The traditional methods of animal identification on a small farm are body marks, ear tags, Radio-Frequency Identification (RFID) tags, retina image recognition, or DNA fingerprinting. Body marks identification methods on horn or skin are cheap, but they are prone to generate errors in data transmission. Ear shear identification is still widely used because it is easy to read after a short training for technicians, and it is also low-cost for maintaining during an animal's lifetime. Moreover, plastic ear tags are the most widely used identifications of animals in many countries, due to its low-cost. RFID utilizes wireless electromagnetic fields for transferring data. RFID technology has the characteristics of mobile item identification and non-contact identification. The use of RFID technology to monitor the entire process of food production and distribution, to achieve the safety of agricultural products from farm to table, can guarantee the quality of agricultural products, and maintain public health (Yiying et al., 2019). DNA fingerprint identification utilizes DNA, an innate barcode within animals, to identify a particular animal farm throughout to table (Bai et al. 2017).

Products identification: The methods of products identification include (a) one-dimensional barcodes such as the EAN/UPC barcode family as the longest established and widely used of GS1 barcodes in retail and especially the GS1-128 and ITF-14 barcodes. (b) two-dimensional barcodes, is a square, including many tiny individual dots. The Quick Response (QR) Code, is commonly used in traceable labels that contain traceability information about the product. QR code is a new means of recording traceability information and is advantageous because it can be quickly read, has a large data capacity, and occupies a small space (Tarjan et al., 2014; Wu et al., 2013). (c) Multi-dimensional barcodes which stores information on the x-axis, y-axis and the colors. Obviously, this provides considerably more information than a two-dimensional code (Bai et al. 2017).

Database: The central database is an elementary component of the traceability system in construction and maintenance. The traceability database sometimes contains collections of data, such as animal identification number, birth data, feeding data, transactions, transfer data, slaughter data and so on. Structured Query Language (SQL) is the standard language used to interactively query and update the database (Admin, 2015).

Network technology: Network technology, which acts just like a bridge, can connect separated traceable information, such as sales, slaughterhouses and farms. Without these network technologies, it is hard to manage centralized data over long distances, to utilize traceable code instantly, to pierce through the limitations among companies, and to give consumers a good experience at a low-cost.

GPS and GIS technology: Global Positioning System (GPS) can help people determine their location by receiving information from at least four satellites in orbits around the Earth. Information System (GIS) is software that can help people use the GPS information to make good transportation plans on electronic maps (Bai et al. 2017).

RFID traceability systems: Meat traceability legislation imposes the implementation and use of Various RFID-based traceability systems for the implementation of real-time traceability management of animals and their products

(Liang et al., 2015; Feng et al., 2013). Kong et al. (2009) developed RFID architecture for meat supply chain security control by using RFID tag to identify animals in farms and organizing the information into farm database. Luo et al. (2010) designed RFID hook for carcasses based on online read and write systems for meat production.

Big data and predictive analytics: Big data are frequently used in many facets of agronomy to enhance knowledge needed to improve operational decisions. Big data in livestock production systems may be generated by operational data acquisition or through use of remote livestock monitoring technology. The predictive analytic framework can be applied in a systematic manner to create information from these data to enhance decision making for livestock production, health and welfare. Using data that is currently collected on livestock operations will facilitate precision animal management through enhanced livestock operational decisions (White et al., 2018).

5 Conclusions

Traceability refers to a simple trace back system which may provide consumers with quality assurances throughout the supply chains, with the aim of reducing the risks of foodborne diseases. Nevertheless, it is important to better understand why implementations of food traceability succeed or fail (Karlsen et al. 2013). When no common theoretical framework of principles and guidelines exists, this can affect the implementation process of traceability in the meat supply chains (Bai et al., 2017). Several different definitions, principles, guidelines and technologies of traceability are currently being applied, which can make the term and the concept of traceability confusing. The present study contributes to literature review of this field identifying the principles, guidelines and technologies with respect to implementation of traceability systems in meat supply chain making its system more effective. The tools for implementation of traceability exist, and most of the technical challenges have been solved. Thus, a compulsory international animal product traceability system has to established in every country. Moreover, it is necessary to develop new technologies and realistic approaches in order to provide automatic animal identification. Further work needs to be done on quantifying the costs and benefits of a traceability system. Currently the companies don't have a detailed picture of their internal processes, so cannot quantify benefits in detail. This leads in turn to skepticism about the advantages of implementation.

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