Application of modern traceability systems and data storage technologies by Hungarian meat companies

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ABSTRACT

In the beginning of the new century the matter of food safety plays an accentuated role through the whole food supply chain. Important issues in this topic are the risk of bioterrorism, impurities in the food-chain and the ascendant customer needs. The solutions of these problems are the introduction of modern quality assurance and traceability systems. The traceability of products and components has received critical attention over the past few years. The purpose of these traceability systems stems from both the economic and food security value of physically tracking batch loads of food and food attributes from the harvest field to any point in the supply chain. In this paper we inspect of spreading of modern quality assurance and traceability systems and we examine the use of information systems and data storage technologies by a survey, which was published for Hungarian meat companies.

Keywords: product tracing, food safety, traceability

1. INTRODUCTION

By January 1, 2005, traceability systems are mandatory for all businesses operating within the European Union's food supply chains, based upon a one-up-one down principle. This means that a business must be able to identify all suppliers and the food, feed or food ingredients they supply to the business. A similar requirement was introduced within the United States, over the period June 2004 to June 2005, as a result of a proposal contained within the Bioterrorism Act.

In the food chain, traceability means the ability to trace and follow a food, feed, food-producing animal or substance through all stages of production and distribution. Stages of production and distribution means any stage including import, from and including the primary production of food, up to and including its sale or supply to the final consumer and, where relevant to food safety, the production, manufacture and distribution of feed. (Definitions at Article 3, EU General Food Law Regulation)

In primary production, traceability has been defined as the ability to trace the history of the product through the supply chain to or from the place and time of production, including the identification of the inputs used and production operations undertaken (British Standards Institute PAS 85:2000). Legislation has been introduced recently to ensure livestock identification and the tracking of livestock movements. Many of the farm assurance schemes require some level of traceability to be in place within primary production.

Market incentives give food suppliers three primary motives for establishing traceability:

- Improve supply-side management;
- Differentiate and market foods with subtle or undetectable quality attributes;
- Facilitate trace back for food safety and quality.

2. IMPORTANCE OF TRACEABILITY

The traceability of products and components has received critical attention over the past few years. The requirements from the individual segments of the food industry may vary. They do have one thing in common, however: they share the need for seamless documentation of the path a product takes from producer, to supplier, up to the consumer (CEBECI at al., 2008).

Food traceability has been analyzed through two different perspectives: operations research and economics. Within operations research and management science, traceability is seen as an information system devised to coordinate information between different divisions within a firm. For example to formulate an optimization problem that minimizes the size of recalled production batches. (SOUZA-MONTEIRO and CASWELL, 2004)

The economics perspective on traceability has two fundamental streams: the demand and supply views. In the former the goal is to determine the consumer's willingness to pay for traceability; the later has focused on the implications of traceability at the firm level. The goal of these literatures is to determine the benefits and costs of traceability, whether the market mechanism can be used to achieve an efficient level of traceability, and how this impacts the power relations of autonomous firms in a supply chain.

Traceability costs are associated with system implementation (e.g., changes in procedures, decreased flexibility, and increased levels of automation, inventory, personnel, and documentation) and maintenance (through auditing). The benefits include increased transparency, reduced risk of liability claims, more effective recalls, enhanced logistics, improved control of livestock epidemics, possible positive effects on trade, easier product licensing, and possible price premiums.

In Europe traceability has been mainly motivated by regulations, while in the US it tends to be motivated by economic incentives. There are several different systems of traceability in agro-food industries. The systems can be characterized by three dimensions: depth (how far up and downstream the system goes), breadth (how many attributes are traced), and precision (e.g., to what extent the origin is correctly identified). There is no single best way to introduce traceability and there is a large variability in the characteristics of systems within and across industries, depending on specific attributes of products or motivations to introduce traceability. (GOLAN et al., 2004)

Public and private decisions to adopt traceability systems have important economic implications (HOBBS 2004, Golan et al. 2003b). There are different motivations to introduce traceability systems: while private firms are motivated by profits, public authorities are more interested in social welfare. Hence we would expect differences between traceability systems developed by private firms and those mandated or influenced by public authorities. The question of what is the efficient level of traceability and whether it is best attained by mandatory or voluntary rule is an important one (GOLAN et al., 2004).

Traceability alone does not contribute to higher levels of safety or other quality attributes; it only transfers information along the supply chain. In order for traceability to affect quality it must be associated with some type of quality assurance mechanism that imposes a set of standards and procedures, and specifies data to be recorded, so that quality can be assured. It is the sharing of information recorded by firms, or by other institutions to which it is passed, which constitutes the bulk of any traceability system.

3. TECHNOLOGIES OF IDENTIFICATION

Traceability can not be solved without high level identification. The identification of food items is based essentially upon two categories of identifier (FURNESS, 2003):

Primary identification (based on the use of biological markers and feature extraction based upon anatomical, physiological, biochemical or molecular, including DNA, methods of identification).

Secondary or data carrier-based identification techniques in which a number or alphanumeric string is used for identification purposes and may be accompanied by other data or information for traceability or process support purposes.

A wide range of reader-supported data carriers are now available for use in structuring and developing process support systems and traceability. The predominant carriers include:

3.1 DNA technique

DNA based traceability uses an animal's DNA code to identify it and products derived from it the product acts as its own label. This code is permanent, unique to the individual (except identical twins) and remains intact throughout the animals/products life history. As a consequence DNA taken from any point along the agri-food continuum can be matched with the original animal's record. In practice implementation of DNA based traceability requires the collection of DNA samples (reference samples) from animals/carcasses. Samples can either be archived for subsequent analysis, or analyzed, and their resultant DNA profiles stored in a database, along with information on animal origins.

Underpinning DNA based traceability concepts are a number of key technologies, namely DNA sampling and DNA analysis. These are integrated through information technology (IT) infrastructure which can also store product related information (e.g. feeding regime, welfare, breed, process history) and incorporate data algorithms to enable the matching of meat cuts with source animals/carcasses.

DNA samples can in theory be collected from any biological tissue. In practice the DNA sampling function must be low-cost, relatively easy to perform and produce samples in a format suitable for laboratory analysis. There have been a number of innovations in the area of DNA sampling, most notably the integration of live animal identification with DNA sampling through DNA sampling eartags. Additionally systems are being developed which enable the integration of low-cost DNA sampling with conventional abattoir infrastructure to facilitate sample collection in high line speeds encountered in larger slaughter plants. (LOFTUS, 2005)

3.2 Linear bar code symbols

Linear bar codes have been used extensively in retail and supply chain logistics for many years, as an effective means of machine-readable identification and data transfer. A range of symbologies is available to satisfy a variety of data encoding needs, a symbology being the rules determining the way the bar-space symbols are structured to encode character sets. A number or alphanumeric character string encoded within a bar code symbol is used as a means of identifying an item and / or associated information held in a database or other storage facility. Linear bar codes may also carry meta-data identifiers and a limited amount of standalone information, such as expiry date or weight.

3.3 Multi-row bar code symbols, matrix code symbols, composite symbols

A range of two-dimensional, multi-row bar and matrix data carriers is now available, featuring attributes that are complimentary to linear bar codes. Of particular significance in this respect is the ability to carry substantially more data than linear bar code symbols or the same data in smaller space. This capability is engendered in what is generally referred to as the 'portable data file' concept, wherein data is carried as stand-alone machine-readable files. Carrying data in this way constitutes a radical vehicle for process improvement, where opportunities are recognised. They also provide a platform for alternative solutions to data carrier problems that would be difficult or impracticable to satisfy using linear bar codes. Two-dimensional data carriers share some of the features of linear bar codes including read-only capability, line-of-sight reading and low cost data carrier format.

3.4 Radiofrequency identification data carriers

RFID is a transponder technology which is set to play an increasingly important role in the field of logistics alongside existing automatic identification systems such as barcodes. RFID transponders are already in successful use for identifying animals and containers, as part of access control systems, in vehicle immobilizers and in automated production. But the retail and service industries as well as procurement, production and distribution logistics see extended fields of application being opened up by RFID technology. Bringing with it greater efficiency in monitoring and controlling supply chains, whether it be in the reduction of stock levels, the optimization of just-in-time processes, the regulation of traffic control systems in ports and airports, the tracking of shipments or in the monitoring of mechanical or climatic influences on goods during shipment. It is assumed that the greatest potential will be in those sectors that have the highest demands on quality and process reliability, such as the pharmaceutical, chemical and automotive industries. Unlike with barcodes, RFID transfers data between for instance a package (equipped with a transponder) and a data capture unit (reader) with no need for contact or a direct line of sight. It is also possible to capture the data from several different data carriers simultaneously and to read the information through a range of different materials. Furthermore, the data can be tracked in realtime in defined areas. RFID is based on electromagnetic waves with frequency ranges from long wave through to microwave. The technology involves a data capture unit or reader reading the data from a transponder (data carrier with an integrated antenna - also known as a "tag") and/or writing new or additional data to the tag.

4. Traceability in the chain

In recent times, the accurate and timely traceability of products and activities in the supply chain has become a new factor in food and agribusiness (CEBECI at al., 2008). The establishment of tracking and tracing schemes that fit the still dominant network relationships in the agrifood sector with its changing trade relationships depends on sector-wide agreements in a broad range of issues (SCHIEFER, 2008). Increasingly, consumers in many parts of the world demand for verifiable evidence of traceability as an important criterion of food product quality/safety (OPARA, 2004). Main benefits to the costumers:

- Protect food safety by effective product recall, in the case of an emergency
- Enable avoidance of specific foods and food ingredients easily, whether because of allergenicity, food intolerance or lifestyle choice
- Enable real choice to be exercised between food produced in different ways

Traceability systems are of interest to government as part of systems which:

- Protect public health through the withdrawal of food product from sale
- Help to prevent fraud where analysis cannot be used for authenticity
- Control zoonotic disease e.g. tuberculosis, salmonellosis
- Enable control with regard to human and animal health in
- Control epizootic and enzootic livestock diseases through the rapid identification of disease sources and dangerous contacts.
- Monitor /control livestock numbers for subsidy claims

Some species of farm livestock for example in case of cattle the Single-old registration and identification systems is used more than a decade, for purposes of the grant in addition to the breeding, animal health needs too.

The systems were developed by the different characteristics of each animal (BODÓ at al., 2002). The cattle, swine, sheep and goat species, the computer system to operate in all farms, as well as individuals and as regards the movements of the animals. The systems are running by the Agricultural Office Directorate of Animal Breeding Centre (Centre for Animal Husbandry Directorate MgSzH)

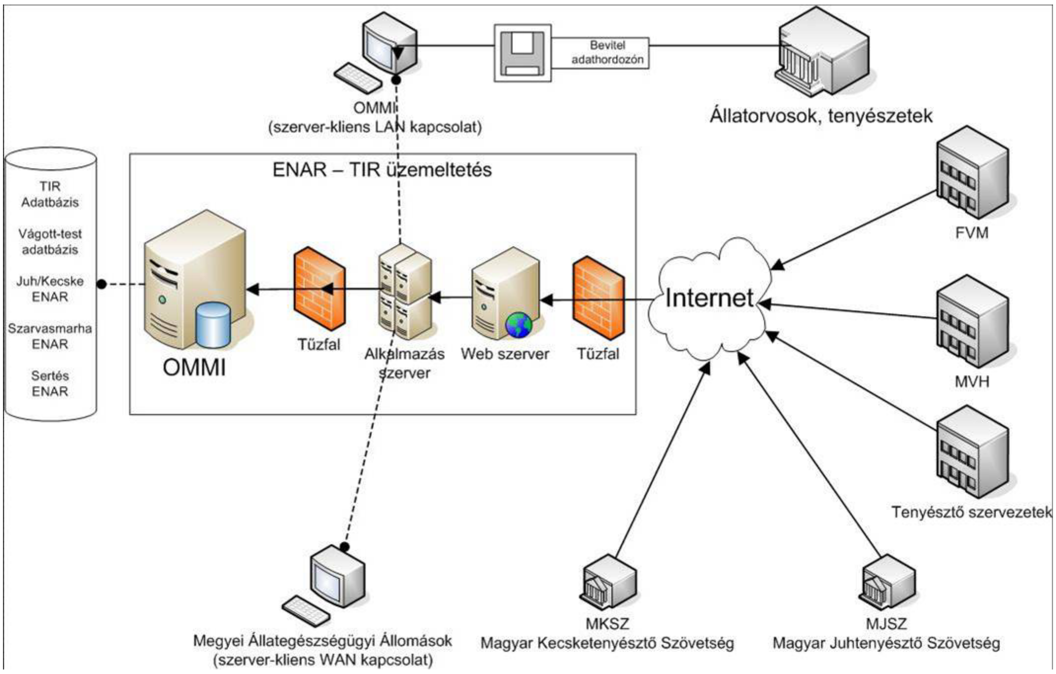

Figure 1. Structure of Hungarian Animal Identification and Registration System
Source: Central Agricultural Office

Benefits of traceability to the company:

- Seamless traceability in compliance with Commission Regulation (EC) No 178/2002
- Support for future requirements with regard to GMOs (GMO: Genetically modified organism)
- Safeguarded quality with paperless quality management
- Limited risk as it is well documented which lots went to which customer (enabling silent recalls)
- Controllable quality at receiving (suppliers are integrated into the value-added chain)
- Transparent batch management for more process and product safety
- Integrated visualization without the need for additional staffing throughout materials resource planning from goods receiving, through inventory, production, packaging, picking, up to shipping
- Fulfillment of company duty
- Transparency of the business-level goods flow as well as internal logistics and inventory control

- Atomization of the process steps in sub-processes with lot number logic and batch tracking and tracing
- Compliance with industry standards, quality and safety norms
- Flexible towards increasing demands of process safety, especially in the realm of food production, throughout all levels of manufacturing and distribution
- Economic and strategic necessity to limit risk in case of incidents (silent recalls)
- Increased consumer trust
- Transparent supplier and buyer tracking and tracing for each shipment at mouse-click speed

Food safety and traceability are keys to companies' business survival and great effort and resources are devoted to them. This is an on-going challenge, demanding the best control systems and day-to-day vigilance on farms, in processing plants and throughout the distribution system. In favour of measure the evaluation of traceability systems implementation in the Hungarian meat industry a survey was made by the authors. The prepared questionnaire with 19 questions was sent by e-mail or post to the Hungarian processing plants, and it was also available by the research portal via Internet.

Figure 2. A screenshot of the research portal

The survey examines (besides the basic data) the used standards, expectations for mandatory regulations, the applied technologies, the authenticity of the traceability systems in supply chain and the quantity of ICT investments. Some results from the survey are shown on Figure 3 and Figure 4.

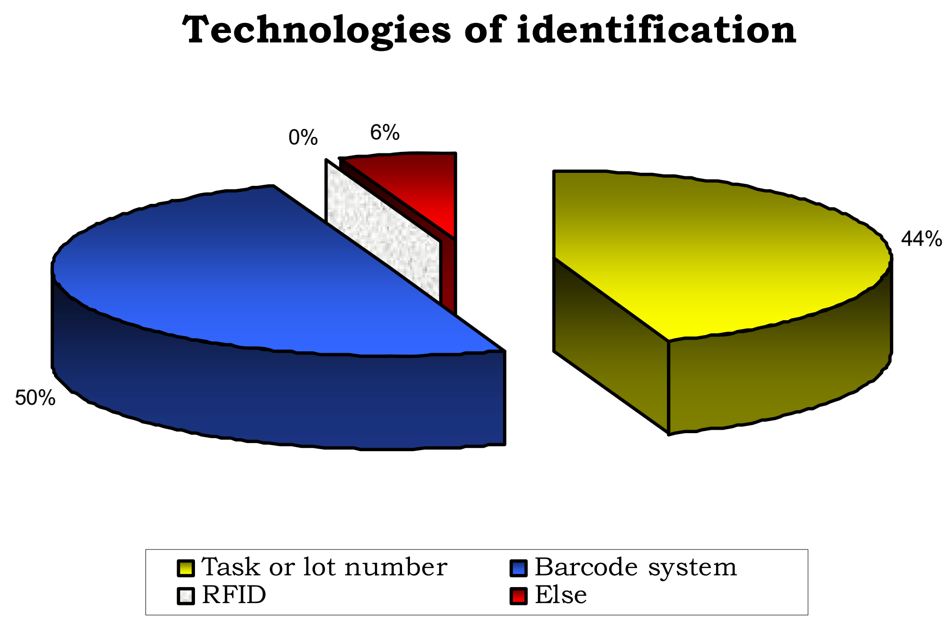

Figure 3. Technologies of identification by Hungarian meat companies

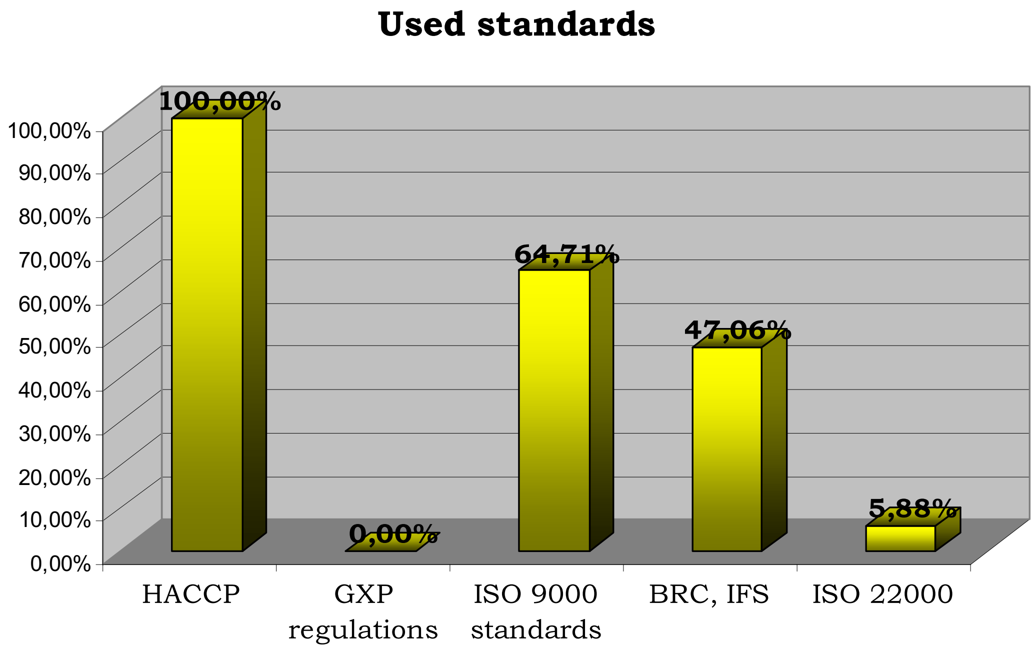

Figure 4. Percentage of using certain quality assurance standards

5. CONCLUSION

Traceability is becoming an important instrument to assure food quality, particularly safety, in agri-food chains worldwide. Many countries are developing mandatory or voluntary programs using traceability to assure animal and beef safety. Motivations for their introduction arise from a variety of scientific, social, and economic factors. The product quality of the Hungarian meet industry meets the high level international standards, the companies are conform to EU regulations, but using high-tech identification and trace system are not very frequent yet.

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