Annotated bibliography
Traceability

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July 2006

Department of Business Administration

Annotated bibliography

Internship

March –July 2006

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Internship, 24 ects (March- July)
Management, Economics and Consumers studies

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Introduction

This annotated bibliography is part of an internship at LEI and PPO. It contains summaries of articles and chapters of books, which are relevant to traceability. In the first part there are nine summaries from articles provided and in part two are the summaries of relevant chapters from three books. After each summary there is a part about the relevancy of the paper for the LEI project. The aim of the LEI project is to gain insight in several aspect of traceability in order to assist actors in the agricultural sector to develop and maintain a good supply chain.
There is a broad range of topics concerning traceability included in this bibliography; from the feed and animal industry, from food manufacturing industry, the fresh produce firms, a case study from the automotive industry, and research on several aspects of traceability, such as the different areas of traceability, its benefits and costs and last but not least the conditions which have to taken in account when dealing with traceability.

I hope that this annotated bibliography contributes to the LEI project and can be very useful for persons who are interested in traceability.

Part one: relevant articles

I. Traceability from a European perspective
Schwägele F., 2005
Meat science Vol.71 (1): 164-173

The focus of this paper is EU legislation on traceability and the technologies needed to implement this system for meat and meat products.

EU legislation on traceability

Article 18 of the General Food Law, i.e. Regulation (EC) 178 (2002) refers to traceability, and in obliged since 1 January 2005. This paper describes the five major points of which article 18 consists and also the responsibilities of food and feed business operators, which are covered in article 19 and 20 of Regulation (EC) 178 (2002).

Traceability can be divided in two key functions: Tracking and Tracing. Figure 1 is a visualization of these two key functions and what is meant by them. Also all the stages of the production, of which producers must collect information in order to be able to trace products, is shown.

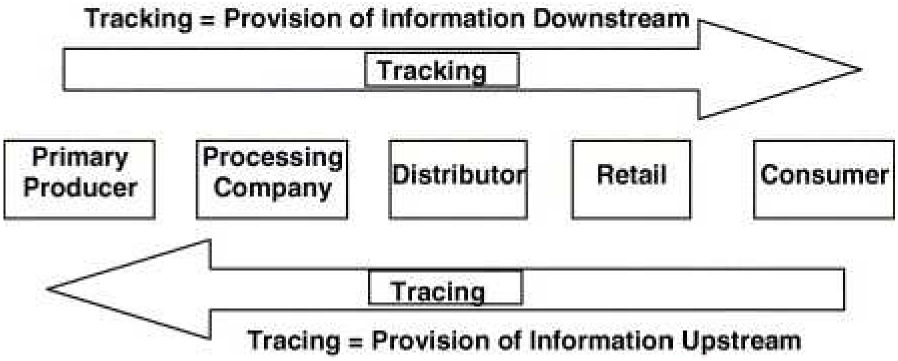

Fig. 1. Tracking and tracing along the food chain.

The main question is: How will the data on different levels be gathered, recorded and stored? It is also necessary that the gathered data can be linked with traceability and it has to be accurate. Food producers can not rely on paper records, systems that are not linked together or manual data entry. They will need integrated traceability data through production, storage, selling and quality control. Therefore there are systems required which are designed to provide instant trace enquiries through highly integrated traceable data.

Identification and traceability systems in meat and meat products

There are several technologies that can be used regarding the foodstuffs origin or history, authenticity, age, composition.

1. *Species identification-protein, fatty acids and DNA based methods:*

- Protein-based methods
  - Proteins have been widely used as species markers. Applicable techniques are e.g. separation of water-soluble proteins by starch, poly-acrylamide and agarose gel electrophoresis.
  - Immunological techniques, used for the qualitive detection of animal species.
  - Proteomics, used to differentiate species, breeds and varieties by their specific protein pattern.
- Lipid based methods
  - Lipid components and fatty acids can serve as target substances for animal species identification. The possible species marker can be determined by gas chromatography (GC) or gas chromatography coupled with mass spectroscopy (GC-MS).
- DNA based methods
  - Polymerase chain reaction (PCR) has been developed into a key technology for species identification in feeds and foods.
  - Polymerase chain reaction restriction fragment length polymorphism (PCR-RFLP) has been used for the species identification of food relevant animals and plants.
  - Random amplified polymorphic DNA-PCR (RAPD-PCR) as well as assays based on single strand conformation pattern (SSCP) were developed for species and variety-specific identification of different animals and plants.
  - Real time PCR can be used for species identification and quantification.
  - Forensically Informative Nucleotide Sequencing (FINS): Sequencing allows species identification without reference material if the generated sequence is available in a database.

2. *Authenticity, geographical, and detection fraud:*

- NMR and MS based methods: Analyses of stable isotopes (^{2}H, ^{13}C, ^{15}N, ^{18}O, ^{34}S and ^{87}Sr) are considered an excellent tool for origin assessment e.g. environmental conditions, soil composition etc.
- Infrared spectroscopy: both near infrared (NIR) and mid infrared (MIR) spectroscopy can be used for analysis of the main components of foods as well as animal feeds inclusive minerals and vitamins.

Technology tracking systems

- The use of the European Article Numbering Association codes (EAN-UCC 2002) is universally accepted as an identification and communication system that facilitates efficient global commerce and improves the effectiveness of recording and exchanging information between supply chain participants. This system consists of three components: Identification numbers, Data carriers and Electronic messages.
- Radio Frequency IDentification (RFID) is using radio signals and can be integrated into a prototype.

Computer modelling can be a powerful tool to estimate the contamination and transmission pathways for pathogens and food contaminants. Risk assessment modelling can be used to help manage food chain risk and make policy decisions regarding the safety of the food chain from food-to-farm. Therefore, any food traceability system requires associated risk assessment models in order to evaluate the potential health risks to humans and animals.

Relevancy for LEI project:
Even though this paper was focused on meat and meat products, the general information about traceability is relevant for companies in all sectors. The various identification systems can be also be used for the vegetables and fruits in the agricultural sector. Finally the paper also shows some technology tracking systems which are making de gathering, storing and accuracy of information more efficient. These systems can be used in every sector, and are more adequate than manual recording of data. An idea for companies in the agriculture is to focus on developing a standard electronic system for a certain group, which can be used by all firms belonging to that group. In that way, firms do not individually develop their own electronic system, since the standard system has parameters that can be used by all firms in that group.

For Example: farmers can try to develop one standard electronic data system with parameters which can be used by all farmers. This means that not every farmer has to develop his own system (since that is very expensive and farmers need detailed knowledge in computer technology), but every farmer can understand and implement the standardized system, so that the whole sector benefits from the standard system.

II. Radio frequency identification and food retailing in the UK
Jones P, Clarke-Hill C, Comfort D, Hillier D, Shears P, 2005
British Food Journal Vol.107 (6) 356 – 360.

The aim of this paper is to offer an outline of the characteristics of radio frequency identification (RFID) technology and briefly discusses some of its perceived benefits and challenges for food retailers in the UK.

What is RFID
RFID is the generic name for technologies that use radio waves to automatically identify and track objects. These objects can be cases, trays, pallets, cages, containers or individual items. There are several methods of identifying items using RFID but most systems consist of a tag, which is made up of a microchip with a coiled antenna, and an interrogator or reader with an antenna. The data transmitted by the tag may provide identification or location details and/or specific information about the product such as price, colour and date of purchase. The data generated by the tags can provide manufacturers, suppliers, distributors and food retailers with up to the minute information on inventory, logistics and freshness.
However, RFID does have some limitations. There can be environmental problems in that radio waves can be absorbed by moisture in the product or the environment, they can be hidden or reflected by metal and the noise from electric motors and fluorescent lights can interfere with RFID communications. At the present time the cost of tags is a limitation on the widespread use of RFID and on the speed at which they may be adopted by the retail industry but these costs are declining rapidly and seem likely to decline further as the technology evolves and as adoption rates rise.

Perceived Benefits from RFID

The following are not only economic benefits for the companies but brings companies also a step closer to the compliance of legislation e.g., legislation on traceability according to the General Food Law, which is obliged by January 2005.

Benefits of having an RFID system are:

- Tighter control and management of the supply chain and of inventory management with attendant cost savings e.g. reduced labour costs.
- Reduced overall operating costs by eliminating manual physical inventory costs (e.g., food retailers often check the delivery of goods into their stores by hand but RFID will allow them to be checked virtually automatically and almost immediately), increasing transport efficiency and accuracy, faster picking in the warehouse and improving stock visibility .
- Reductions in inventory levels (due to “just-in-time” delivery) and information sharing will optimise the assets employed.
- Improvements in customer service, the tracking of customers purchasing behaviour, faster response to product recalls, reduced exposure to public safety risks, and better monitoring of international food movements.
- FoodTrace, the EU funded concerted action group, whose primary objective is to develop a practical framework to identify every item as it passes through the food chain, increasingly seems likely to harness the power of RFID technology. This means that RFID tags are currently seen as the best way of fulfilling this requirement. Finally, benefits are also claimed for RFID technology in relation to food safety regulations e.g. fast recalls.

Challenges for RFID

In order for RFID to become “truly transformational”, there are some challenges which first need to be overcome. These are as follows:

- Companies need to undertake a fundamental strategic review of their business processes and of their relationships with suppliers and distributors. They must emphasize on the total costs of establishing an RFID infrastructure throughout the retail supply chain and weighing the costs, (e.g. the cost of tags, readers and associated infrastructure) and of the application integration that needs to be installed, against the anticipated benefits.
- These RFID systems will automatically collect a massive and continuous stream of data and the storage and transmission of this data will place severe strains on many retailers’ current ITC infrastructure. At the same time retailers will also need to integrate their RFID systems and the data they generate with their other functional databases and applications such as accounts and customer relationship management.
- The introduction of RFID technology will also generate major training needs for food retailers and their suppliers and distributors, to allow their employees to use the new systems and master new job functions.

Relevancy for LEI project:
This paper gives a brief description of RFID and its benefits and challenges. It is a relevant paper for the LEI project, because it can be used to persuade the different actors in the agricultural sector to implement or at least think about the RFID system. Especially the economic benefits which are described of the RFID, are an eye catcher for companies which first did not even considered this system. And the fact that it also contributes to the compliance of companies with traceability legislation shows that this system has multiple functions and must be considered as a possible "must-have" system for the food-chain.

III. Computerised parts traceability: An implementation case study
Sohal A.S., 1997
Technovation Vol.17 (10): 583-591

This case study describes the planning, implementation and problems of a parts traceability system in an automotive parts manufacturer, Nippondenso (Australia).

Nippondenso (Australia) is a daughter company of Nippondenso (Japan) one of the leading automotive parts manufacturers in the world, and manufactures hundreds of products and multiple variations of the same product (e.g. radiators, heaters, blowers etc.).

The need for traceability

- Towards the end of the 1980s Nippondenso (Australia) did not fully implement a 'First in first out' stock accounting procedure and, without full traceability, could not identify which batches of raw materials were used in finished goods.
- Nippondenso could not determine precisely its level of stocks; mainly manual recording which caused errors in inventory transactions. Stock records quickly became unreliable and excessive paper handling was inhibiting the efficiency of workers.
- As the Australian car manufacturers needed to fully identify and trace every automotive component to assure product quality, it also had an effect for automotive parts manufactures.

To comply with this requirement it was obvious that there was a need for automated recording, but no one had developed such a system yet. Taking the technological innovations in consideration, Nippondenso thought about developing a fully computer integrated manufacturing (CIM) system. Although top management had limited computer skills, the Information Systems manager educated the top managers in software applications. Soon after convincing them that computers were an essential business requirement, a comprehensive computer manual was written which was titled NEMO (Nippondenso Effective Management in the Office). The manual gave a step-by-step explanation of the improvement to Nippondenso (Australia) that the implementation of a fully computer integrated manufacturing system would have.

Planning, developing and implementing the traceability system

Next the office systems five-year plan was developed and it explained the policies necessary for implementation to senior management. "Nippondenso's Mapics DB software needed to be hooked up to an IBM AS400 computer. Using Mapics DB as the centra1 software program, individual applications were then added to the existing network. In the early 1990s Electronic Data Interchange (EDI) was connected to Mapics DB and implemented to provide quick order responses from suppliers and automatic ordering from customers.

In cooperation with Databars (Australia) Pty Ltd, an expert in systems design and implementation, the database and barcode system was developed according to Nippondenso's concepts and specifications. Every stage that each component passes through the Nippondenso automotive plant is recorded by the computer to ensure traceability. The key elements of the system are shown in table 1.

Table 1: key elements of the system

1 Receipt of goods	5 Material usage
2 Issue to the work centre	6 Material ordering
3 Starting a job	7 Finished product dispatch
4 Recording production	8 Parts traceability functions

As a trial, the system was first piloted in one section and when problems were overcome, the system was progressively installed throughout the factory. Two persons from the logistics department undertook the difficult job of introducing the full traceability system to the shop floor employees. These two were chosen due to their experience as store men who understood the necessary communication required on the shop floor.
Overall, senior management was satisfied with the speed of implementation, considering the nature and extremity of change in operation from a manual oriented to a computer dependent shop floor.

Problems experienced by the company during implementation

- Concerns with the delegation of control of the system, because internal conflict existed regarding which department the systems manager would come from (either Electronic Data Processing or Logistics). The aptitude of the chosen candidate was considered crucial to the ongoing success of the system, as traceability systems and the management of them are quite complex.
- Lack of communication between senior management and the Information Systems department appeared to hamper the efficiency of the implementation of the traceability system. So for success within the company, a multidisciplinary approach is essential.
- Not enough discipline within the organisation. Given the dependency of the computer program upon the accuracy of information entered by the operator, strict procedural guidelines were required to be followed, but this was not always done by the factory floor workers. Therefore commitment to training is one way Nippondenso is continuously improving internal discipline. The team leader is also constantly encouraging the workers to perform at higher levels as well as personally instructing workers on overcoming recurrent problems.

Benefits experienced by the company due to implementation

- Traceability is more than a system to trace the sources of problems. It has become a factory management system where daily production can be planned, machine/line utilisation and efficiency can be analysed, up to date work-in-progress is monitored and internal or external parts shortages are notified.
- Errors previously caused by paperwork recording, labour costs and the number of store men required, are reduced due to the traceability systems.
- Nippondenso can now trace which batch of material went into any faulty product. This allows specific identification (labelling) of a product and accurate recalls.
- Nippondenso's increased customer responsiveness and has increased its competitive advantage.
- The entire workforce is involving itself in traceability as computer familiarity improves confidence amongst employees. This has visibly raised a feeling of involvement and motivation under the employees.

Conclusions

1. Top management understanding of computer based/ computer-integrated manufacturing (CIM) is essential. Without this, little wil1 be achieved.
2. A long-term plan for CIM is necessary. A stand-alone system will do little to improve the overall competitiveness of the organisation.
3. New systems will almost always involve outside actors (e.g. suppliers and consultants). Relationship building between all the parties involved is essential for successful introduction and implementation.
4. Benefits of the new system must be communicated and understood by everyone in the organisation. The fear of the unknown must be overcome by educating/training and discipline employees to become involved with and use the new system in the proper way.

Relevancy for LEI project:

This case study is useful for the LEI project, because it shows that even though most employees or mangers of a company are not familiar with (innovative) computer systems (which is possibly also the case for a lot of agricultural companies), it is still possible to implement computerized traceability systems and even be the leader in your industry. It shows the steps which you have to take, and the important lessons learnt from this case study are that the financial evaluation when developing a (traceability) system should not be based strictly upon return on investment but must be seen as a necessary step to consolidate business relationships with customers and suppliers. And finally, the importance of empowerment of the employees is emphasized in this paper, without education, involvement and motivation of the employees, even the best traceability system is likely to fail. So even in small agricultural companies, the affect of empowerment of employees must not be underestimated.

IV. Traceability 2005 and beyond
Baxter S., 2004
Food Processing Vol. 73 (5): 25-26

The General Food Law Regulation (178/2002) has far reaching consequences as of January 2005 for the traceability in the food business.

Traceability has three main roles within food companies:
1. Providing information within the business to assist with process control and management.
2. Supporting the effective withdrawal and recall of products.
3. Providing more detailed and reliable information for consumers about the products they are purchasing.

Although the benefits of traceability systems are evident, there are still a lot of challenges, uncertainties and problems before such systems can be implemented:
1. How to store the huge amount of products and raw materials present in the food chain?
2. Which system is suitable, taking in consideration that the traceability data needs to be kept for five years, and needs to be accessible when needed?
3. Which suppliers and buyers must be included in developing a traceability system in ones supply chain and are they willing to share their information?
4. How will the costs be distributed, since such systems are often expensive?

Since there was before never a legal requirement by law for the establishment of traceability systems in the food supply chain, it is especially for the small companies very difficult to comply with this law by January 2005. However, most of the larger food manufacturing companies in the UK often already had traceability systems in place due to agreements they made within their industry or their own supply chain. Retailers will collaborate only with companies who are able to meet the new requirements and therefore it is feared that they will decide to deal only with large manufacturing and “Quick-to-adapt” companies, leaving a lot of small companies aside.
Therefore it is necessary for especially small food manufacturing companies to react fast and try to meet the requirement. These companies must consider collaborating, with each other, or with their supply chain. Together a system can be developed and implemented which works for all partners or if they already have record systems in place, they must look for possibilities how these systems can be adequately integrated.

Communication and co-operation between companies are very crucial, since talking with fellow manufactures, suppliers and customers will generate a lot of useful information and result in a reliable traceability system which is beneficial for all the links in the supply chain.

<u>Relevancy for LEI project</u>
See under paper 5.

V. Time to make ends meet
Chomka S., 2003
Food Manufacture Vol.78 (4): 35-36

Food safety claims that guarantee the integrity of food are going to be a major marketing issue.

By 2005 every company must have their traceability system in place. However, the means of achieving fully supply chain traceability has not yet bee determined. Producers use different codes and traceability methods.
Even though some manufactures already record their data, it is possible that even these companies have to adjust or switch to a more specific system because there could be much tighter controls obliged. The General Food Law is a framework on which people or industries can hang more detailed regulation. So there is the possibility to establish more specific traceability requirements in different sectors (this is already the case for e.g. organics, European beef trace systems). In the future it is expected that more sectors will follow this road, since detailed traceability systems are not only useful for safety but can also be used as a marketing topic.
As consumers are now a days more concerned about food safety, these systems can regain consumer's confidence, enhance their trust in the food industry and companies can acquire now potential customers.
It is a necessity that companies work together to develop traceability systems and that all the links in a supply chain record their data in a way that can be universally understood. Because a good system is not only a marketing topic, but can also be an insurance policy for manufacturers (e.g. traceability is going to save a firm millions if the firm has such a system if a crisis comes along).

Relevancy for LEI project
Paper 4 and 5 are useful for the LEI project, because they emphasize how important it is for small companies to comply with the traceability law of the General Food Law. Paper 4 states that retailers will not work with companies who do not have an adequate traceability system, even though they have a long term relationship. This is because not only one company will be affected if something is wrong with its system, but the whole chain. Therefore nobody is willing to work with a company which does not have a (reliable) system. Since there are a lot of small companies in the agricultural sector, the message of this article is to warn them what the consequences can be if they do not have a good traceability system. Paper 5 explains that having traceability systems can also be used as a marketing tool, something that can be useful for all companies, including agricultural ones. These two papers are written quite understandably and can therefore be used as background information for workshops/information days to introduce this traceability topic to people who are not yet familiar with it.

VI. Recent developments in animal identification and the traceability of animal products in international trade
Barcos L.O., 2001
Revue-scientifique-et-technique-office-international-des-epizooties
Vol.20 (2): 640-651

Globalization and traceability
The steady growth that is occurring in world trade of animals and animal products needs to be accompanied by guarantees that trade is safe for public and animal health. One of the components to guarantee safe (food) trade is having a traceability system. To trace or track animals and animal products, the various links in the chain must be defined, as must the individual tracing system for each link in the chain.
New forms of trade, with cheaper and faster transportation and electronic systems, longer periods and diverse types of conservation and warehousing, bring an enormous challenge to traceability. One of the challenges is that traceability systems can sometimes be considered useless, because when a product with a long shelf life (e.g. 7 years) is eaten just before the *Best before date* expires, there is a possibility that the producer and the manufacturer may no longer exist.

Challenges in traceability systems
Although registration and traceability systems in various countries have fixed elements, in many cases they can also be conflicting and complex. In some cases there is variability in systems used within countries. This variability in registration systems depends on a series of factors, such as the species, type of production, national legislation and livestock production customs. In many countries, this is an issue of debate among the different sectors with a view to meeting local and international requirements. The key is to satisfy the needs of the various links in the chain, creating confidence without increasing costs or erecting trade barriers.

There are different links in the chain which have to be considered when developing such a system.

- **Primary producer**
  The primary producer is a very important link in the chain; he/she implements the production process, and is chiefly responsible for delivering a healthy and disease-free animal or product to the next link in the chain.
- **Transportation**
  Transportation is another dynamic factor with enormous influence over the sanitary aspect of the production chain. Vehicles should be individually identified and registered in line with the legislation in force in each country.
- **manufacturing**
  Manufacturing is concerned about the places were animal products are manufactured or processed (e.g. slaughterhouse). A product label must identify the manufacturer that produced the product and records must be maintained of the components of manufactured products, raw materials and anything directly or indirectly related to the final product.

- **Products**
  An animal can be divided into many different parts, each of which has a different number. A traceability system for animal products is very complicated, because through a number of different processes and combinations of components, a wide variety of products can be obtained from a single animal (e.g. cut of meat to potted meat).

Identification and traceability systems

Individual identification of animals has been used for many years to indicate the ownership of animals. Different elements are used to identify animals: convenience and ease of use, easy to read, durability, animal health and welfare, harmless in food, tamper-proof and costs.
Analysis of the possibility of harmonising and standardising aspects to individual identification and traceability is advisable (e.g. national definitions, terms, codes, etc). Factors which have to be considered when developing an identification and traceability system include:

1. Objectives: what are the objectives of the systems and what is the expected outcome.
2. Policy: each countries situation, different decision-making level etc. must be taken inconsideration.
3. Costs & Financing: how will costs be distributed (e.g. public or private sector, for some countries financing is a limiting factor).
4. Production systems: how to deal with the variability in systems between and within countries.

Relevancy for LEI project:

The problems experienced with animal products, is also a problem for agricultural products. There are multiple similarities between animals and fruits and vegetables. First, agricultural products can also be used extremely diverse (e.g. form pineapples they use the pulp, but the fruit peel can also be used for juice). Secondly, fruits and vegetable bought from all over the world are manufactured and processed in various ways (e.g. bottled vegetables, conserved fruits, mixed salads etc.) These products come also from every corner of the world, and also need a good traceability system. This paper gives an overview of the aspects which has to be taken in consideration when trying to develop traceability systems for diverse products in a globalizing world.

VII. Perspectives on traceability in food manufacture
Moe T., 1998
Trends in Food Science & Technology Vol.9 (5): 211-214

Traceability

Traceability can be divided in two ways: chain traceability and internal traceability.

- Chain traceability: is the ability to track a product batch through the production chain (harvest, transport, storage, processing, distribution and sales).
- Internal traceability: is the ability to track a product internally in one of the steps in the chain (e.g. the production step).

The term traceability can be used in four contexts, and 1 and 2 are the focus of this paper:

1. Product: materials, origin, distribution etc.
2. Data: calculations and data generated.
3. Calibration: it relates to measuring equipment to national or international standards, primary standards, basic physical constants or properties, or reference materials.
4. IT and programming; it relates to design and implementation back to the requirements for a system.

Product traceability is first of all based on the ability to identify products uniquely. Product identification can be made by physical marking on the product or its package or by use of records e.g. when information cannot be marked on the product during processing. A traceability system can be split into two elements: 1) the routes of the product (routes describe the path along which, and the means by which, products can be identified throughout the manufacturing, distribution and retail system and 2) the extent of traceability wanted (extent defines the scope of traceability).

Core entities:

The fundamental core in a traceability system is the ability to trace both products and activities. Products and activities are called core entities; an entity is what can be individually described and considered. Activities describe the route of the product or the activities that influence the quality of the product (e.g. buying, selling, handling, boiling, packaging etc). To make the concept more operational, we have defined for each core entity a set of essential descriptors that must be included in order to secure ideal traceability of products and activities. Each of the essential descriptors is then qualified using sub-descriptors taken from purchase, production, measurements etc. (see figure 1).

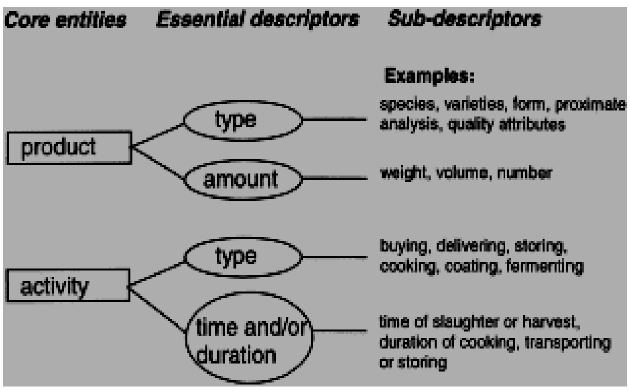

Fig. 1. Fundamental structure of a traceability system.

Traceable resource unit:

Unique identification and traceability in any system hinges on the definition of what is the batch size, also called the traceable resource unit (TRU). TRU is an unique unit, meaning that no other unit can have exactly the same, or comparable, characteristics. A consistent definition must be maintained but what constitutes a TRU is decided by the system designer. The identification of a TRU may change during the product route. This results in a new TRU which must be given a new identification different from that of any of the original TRUs. The size of a TRU may also change, for instance when one batch is split into several batches. The desired degree of detail of information varies according to the purpose.

The use of computers enables a larger amount of data to be handled and thereby it becomes realistic to develop traceability systems with very detailed information about both the product and its processing history. However, it may not always be possible to establish the ideal traceability system. Where loss of traceability of a product is unavoidable, effective alternative methods of control should be ensured.

Chain traceability: Establishing chain traceability systems has many advantages (see box 2). In principle there are two main ways of managing information in the chain where full traceability is required:
1) Information is stored locally in each of the steps in the chain sending only product identification information along with the product.
2) Information follows the product all the way through the chain.

Box 2. Advantages of chain traceability

- Establishes the basis for efficient recall procedures to minimize losses
- Information about the raw material can be used for better quality and process control
- Avoids unnecessary repetition of measurements in two or more successive steps
- Improves incentive for maintaining inherent quality of raw materials
- Makes possible the marketing of special raw material or product features
- Meets current and future government requirements (e.g. confirming country of origin)

Internal Traceability: Having internal traceability within a step in the chain also has its advantages (see box):

Box 3. Advantages of internal traceability in the production step

- Possibility for improved process control
- Cause-and-effect indications when product does not conform to standards
- Possibility of correlating product data with raw material characteristics and processing data
- Better planning to optimize the use of raw material for each product type
- Avoidance of uneconomic mixing of high- and low-quality raw materials
- Ease of information retrieval in quality management audits
- Better grounds for implementing IT solutions to control and management systems (e.g. Computer based quality management systems, Laboratory Information Management Systems (LIMS), Manufacturing Execution Systems (MES) and others)

Relevancy for LEI project:

This paper helps to understand the different aspects of traceability and traceability systems. Also for agricultural companies it is relevant, because it can be used as a guideline when thinking about the traceability system which fits the company best. It makes a clear distinction between internal and chain traceability systems.

Farmers could mainly focus on having an internal traceability system, since it is their task to follow their products only one-step forward. This paper also emphasizes that companies have to select a tracing system according to which level of information they want to know. So the purposes of the system and de level of detail required are aspects which have to be taken in to account when choosing a traceability system which fits the company.

VIII. Motivations of fresh-cut produce firms to implement quality management systems
Fouayzi H., Caswell J.A., Hooker, N.H., 2006
Review of Agricultural Economics Vol.28 (1): 132-146

In the food industry there is a rapidly increasing interest in quality assurance for attributes like food safety, taste, appearance, and production practices. Quality management systems (QMS) are the major vehicles used by companies to respond to this interest.
QMS currently used in the fresh-cut produce industry are: Hazard Analysis Critical Control Points (HACCP), Good Agricultural Practices (GAP), Qualified Through Verification (QTV), Good Manufacturing Practices (GMP), in-house systems (IHS), ISO 9000, Certified Organic and third party programs managed by Silliker Laboratories, Primus Laboratories, American Institute of Baking (AIB), and the National Sanitation Foundation (NSF).

Implementation of QMS depends on the benefits and costs of firms
Benefits: a company receives a higher price for its high quality product, there is a reduction in costs, improved understanding of the companies own quality system, which leads to more efficient controls and better plant performance, fewer consumer complaints, less quality variability. There are several other motivations to implement QMS such as better management of transactions costs between buyers and suppliers, management of liability exposure, compliance to governments, international trade or customer requirements.

Costs: personnel training, acquisition of new equipment for control and testing, costs associated with the day to- day operations such as continued training for employees, recording, testing and consultants' fees.

The results of the three main topics of the survey executed in this paper are as follows:

- **Adoption of and satisfaction with QMS in the fresh-cut produce industry**

All the surveyed firms had one or more QMS in place. HACCP is the most dominant system, used by most companies, although companies often use it in combination with other QMS.

- **Changes experienced by firms with QMS adoption**

The surveyed firms with QMS adoption experienced improvements in product traceability, product quality, and the quality of data available for decision making. There were also improvements in the ability to maintain current customers and attract new ones, satisfaction with sales, the quality of purchased inputs and satisfaction with access to the domestic market. There were reductions of product failures, product recalls, customer complaints, and warranty claims. However, it was also shown that implementing QMS results in an increase in costs (e.g. record keeping, monitoring productions process, laboratory analysis etc.).
Due to QMS adoption, firms work more on quality assurance with their customers and suppliers, inspect inputs more frequently before signing contracts with suppliers, and have their products inspected more often by customers. Also the likelihood of signing long-term contracts with customers or suppliers also increased.

- **Factors related to satisfaction with QMS**

Most firms reported that they were satisfied with QMS. Their satisfaction with QMS is correlated with several aspects. Below there are some examples:

  - Overall satisfaction of QMS adoption rises, when the satisfaction with the quality if inter-departmental communication or data for decision making increases.
  - Satisfaction with QMS increases as the tendency to sign long-term contracts with suppliers increases. After implementing QMS, firms tend to keep the same suppliers by signing long-term contracts to reduce uncertainty and information problems—key components of transaction costs.
  - An increase in satisfaction with QMS is correlated with firms spending more time drafting product specifications with their suppliers.
  - An increase in satisfaction with prices also is related to greater satisfaction with QMS. This suggests that a premium is being paid for better quality products.
  - Having a larger number of customers to choose from is correlated with firm satisfaction with QMS.
  - Finally, firms that are diligent regarding spending more time with their suppliers and customers when negotiating contracts and inspecting inputs are more satisfied with QMS.

Two firm characteristics were shown to be associated with overall satisfaction with QMS for this group of surveyed companies. Processors are more likely to be satisfied with QMS than firms that do not process as part of their business (e.g., growers or distributors). Also, having a parent company or being part of a multi-plant operation was associated with satisfaction with QMS. Firm size was not significantly associated with firms' satisfaction with QMS.

Conclusion

This survey of the fresh-cut produce industry illustrates the increasingly central role of QMS adoption in the food industry. The surveyed firms in the fresh-cut produce industry are clearly motivated to adopt QMS. QMS adoption affected intra- and inter-firm factors. Intra-firm effects include improved management and efficiency through an enhanced understanding of the quality system. Inter-firm effects were the ability to identify other firms in the supply chain and facilitate trade with them. Firms with QMS increased their frequency of signing long-term contracts with other firms in their supply chain. Since inter-firm activities are mainly associated with transaction costs, these effects help firms decrease such costs. Most of the findings are consistent with the literature on what motivates firms to implement QMS. However, in contrast to previous literature, firm size was not significantly related to the number of QMS adopted or satisfaction with QMS among the survey respondents.

Relevancy for LEI project
Companies in the agriculture most not be too focused on having a traceability system in place, only because it is obliged by the GFL. This paper shows that QMS has many benefits for the firm itself and for its partners in the supply chain.
These include improvement of product traceability. Even though agriculture has many small companies, the survey shows that even small firms are satisfied with QMS. It can be said that all firms in the agriculture must focus on implementing QMS, because it does not matter what size the firm is, implementing QMS always has advantages for the company and plays a major role in the traceability of products. Perhaps for some firms, having sophisticated QMS in place will be sufficient to trace products to the level they need.

IX. Information Asymmetry and the Role of Traceability Systems
Hobbs J.E., 2004
Agribusiness, Vol.20 (4): 397-415

There are three functions of traceability systems:

1. Ex post reactive systems: allow the trace-back of affected products if there is a food safety problem. The private en public sector costs are reduced because of the ability to quickly implement recalls and to identify the source of the problem.
2. Ex post systems that facilitate the allocation of liability: hereby there is less risk that a firm will get civil legal action against it when there is a unsafe product produced, and there is a smaller chance that the firms reputation/brand will be damaged. So traceability systems also perform an ex post information function.
3. Information systems that provide ex ante quality verification: this leads to a reduction in information costs for consumers.

There are two figures which illustrate the functions of ex post and ex ante information systems:
Figure 1 illustrates the two functions of an ex post traceability system: reducing market externality costs and enhancing liability incentives.
There are three main paths in this figure: a) voluntary industry traceability, b) mandatory traceability, and c) no traceability.
There are five different costs identified of which the last three are additional costs when there is a food safety problem:
* Costs of implementing a traceability system
* Costs of production which is affected by a firm due diligence decision
* Costs due to market penalty
* Potential liability costs to the firm
* Externality costs, due to reduction of consumers trust in the industry
Finally the expected revenues for the firm from each path are then indicated.

Figure 2 represents an ex ante verification system. Again there are three main paths: a) voluntary quality verification and labelling, b) mandatory quality verification and labelling, and c) no verification and labelling system.
There are two costs that affect the payoff to the firm:
* Costs of implementing a quality verification system
* Production cost of a high or low quality product.
Finally the benefits of each path are given.

Taxonomy of traceability systems
Looking at the different cost/benefits of the different paths, it is clear that a simple model of a traceability system does not exist. Traceability systems for specific commodities have different objectives and respond to different information asymmetries. Often the key features of the traceability system depend on the attribute that drives its development. A taxonomy of traceability systems illustrates the multidimensional nature of the information problems related to food safety and food quality. There is a table which describes the relation between information asymmetry and the role of traceability systems (table 1). This table provides examples of food quality and food safety attributes, identifies the information problems that accompany these attributes and indicates the function that a traceability system could play in addressing these information problems. The table also highlights the need to consider fully the nature of the information asymmetry problem before implementing a traceability system.

Relevancy for the LEI project:
This paper gives an overview of the costs and benefits of different paths that can be chosen and the relation between information asymmetry and traceability systems. It emphasizes that firms must first take a good look at and consider their motivations before selecting a traceability system, because traceability systems have different functions. Since there is also in the agricultural sector the information asymmetry problem, this article is useful in guiding firms and also the industry or involved governmental institutions to make the right decision concerning traceability systems.

Part two: relevant chapters from books

X. Food Safety Law in the European Union: an introduction
Meulen van der B., Velde van der M., 2004
ISBN: 9076998515

This book is about food safety Law in the European. The different elements of food law are analysed, taking the General Food Law as a focus point. It is a good introduction for people who do not have a background in law, it is written clear, there are good references and it has clear diagrams which make the division of powers, institutions and the available tools easy to understand.

Chapter 7 The General Food Law: general provisions of food law, p.147-160

Definition of food, article 2: "food" or "foodstuff" means any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonable expected to be ingested by humans.
Definition of food businesses operator article 3: the natural, are legal persons responsible for ensuring that the requirements of food law are met within the food business under their control.

Chapter 10: Food handling p.185-192

Hygiene
Since the development of Regulation (EC) No 852/2004 of the European parliament and of the council of 29 April 2004 on the hygiene of foodstuffs, there is a general obligation on food business operators to ensure that in al stages of production, processing and distribution food under their control satisfies the relevant hygiene requirements. The bases of these requirements are the HACCP principles. The aim is to prevent hazards before hand, instead of taking action after wards. Remarkable is the fact that it is left to the industry to formulate the specific standards that will be used, although the annexes of the regulation gives general hygiene requirements for primary production and for all business operators (mostly about cleanness and prevention of cross contamination). So it can be seen as a mix of self regulation and obliged regulation.

Tracking and tracing
The purpose of traceability systems is to enable food safety problems to be identified at the source and across the food chain. Food business operators must keep records of exactly where their food material originated and where it went. Manufactures of products of animal origin were already familiar with these systems, but the GFL (article 18) broadens the scope of traceability to all foods. Traceability requirements go only one step up and one step down the food chain. Food business operators must be able to identify their own sources and customers, except the final consumer. To reconstruct the whole chain is the responsibility of the authorities, and therefore traceability information has to be made available to those authorities on demand.

Identity preservation

At this moment there is a heated controversy as to what extent the *Identity preservation* is required. The more precise the *Identity preservation,* the smaller the losses in case of a food safety problem and the smaller the number of food business operators, affected.
Therefore the business operator has to define which level of *Identity preservation* is achievable. Then the court will decide till what extent the food business operators will be held liable for damaged suffered due to suppliers unjustly implicated food safety problems, particularly where better tracking systems might have prevented them.

Withdrawal and recall

GFL article 19 describes the actions that have to be taken when a product may cause food safety problems and the responsibilities for food business operators are explained. If a food business operator has reason to believe that a food is not in compliance with the safety requirements, it has four duties:

1. Withdraw the food immediately from the market.
2. Inform the authorities immediate when having any reason to believe that there is unsafe food on the market.
3. Effectively and accurately inform consumers and recall the products if they are already sold to consumers.
4. Collaborate with authorities to take actions to reduce the risks.

Because it is not required to include consumers in their traceability systems, it is normal that business operators use the publicity in the media for their recall-actions if there is a food-safety problem.

Relevancy for LEI project:

Since it is very difficult not to get lost in the many regulations and directives that are written, this book is a good guideline to get a feeling of what is going on in Brussels. Chapter 10 is relevant for the LEI project, because it gives a good overview what is written in the GFL about traceability. This chapter can be a good source of information when trying to make farmers understand more about the GFL and getting them familiar with their responsibilities and what the authorities are expecting from them.

XI. Safety in the agri-food chain
Luning P.A., Devlieghere F., Verhé R. 2006
ISBN: 9076998779

This book covers the total agri-food chain. There is mainly an overview of the food production chain, safety risk factors, quality assurance systems, risk management, the different actors involved in the chain and tracking & tracing.

Chapter 10: Traceability in the food supply chains, 439 - 470
By: Trienekens J.H. and Vorst van der J.G.A.J.

Tracking and tracing has a broad scope. Van der Vorst (2004) defined three chain traceability strategies:

- Compliance-oriented strategy: the organisation only complies with legal regulations with the help of end-of-pipe techniques. The chain is usually fragmented since each company individually complies with (legal) demands.
- Process improvement-oriented strategy: the organisation strives for control of product traceability within its link by means of production-integrated measures in order to achieve compliance with legal regulations as well as improved process efficiency.
- Market-oriented (branding) strategy: with this, organisations aim for the establishment of full traceability within the supply chain to achieve competitive advantage (by creating added value in the market place). This requires a chain structure in which the individual links work intensively together to open new markets. Integration and common goals are key aspects.

Information decoupling point

When goods are exchanged between enterprises that are part of a supply chain, the information is de-coupled from the products and only aggregated information accompanies the product further through the chain. Traceability is then guaranteed via coupling of the aggregated product properties to detailed product properties by codes or certificates. These codes or certificates linked to products must give access to the information left behind at the links upstream of the chain. For companies this means that they must implement information systems that are able to identify, register and track the product throughout the chain, while preserving the link between aggregated and detailed product information. The point at which this de-coupling occurs is called the information de-coupling point (Beulens et al., 1999), see figure 5.
The major advantage of de-coupling information from the product is that an information overload is prevented, while the detailed data is still accessible by means of identification.

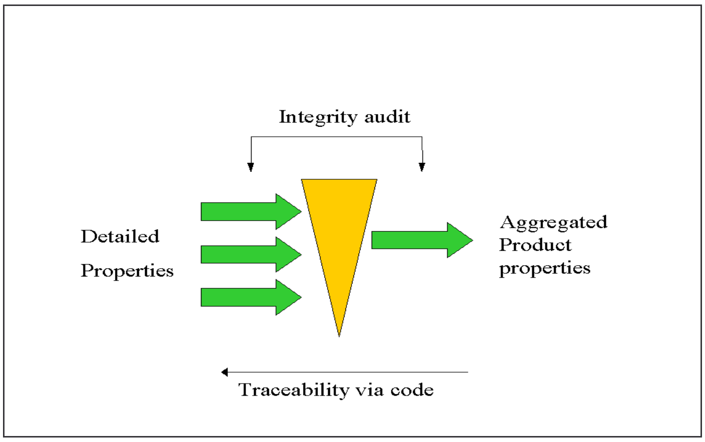

Figure 5 Information de-coupling point (IDP)

Traceability difficulties in the food industry

A selection of the factors that have the most effect on the complexity of traceability is presented below:

- Batch or continuous production. If production takes place in batches, identification can be retained by batch. However, in the case of continuous production (e.g. milk) identification can only be retained by time of production;
- Many sources of batches of raw materials (home and abroad). Because of the internationalisation of food chains and networks, sourcing becomes more and more international. This makes traceability hard to achieve;
- Many actors with formal and informal relationships in the chain. In the food chain transactions often take place at arm's length. Sound transaction administration is often lacking;
- Lack of connections between physical and administrative product flows. In general, one could say that food chains and (chain) processes within them are complex systems. Consequently, implementing traceability and transparency systems is also complex;
- Perishable character of products. For certain materials storage life constraints apply. As a consequence, using up materials according to 'first in first out' (FIFO) may not apply and different batches of the same product, but of different age, cannot be grouped and must be handled separately.

Research projects in the food industry in the Netherlands identified an extended list of product and process data of importance in the food industry (Trienekens, 2001). In this section two examples of traceability requirements at companies in different food chains are given: one from a distribution company in the fruit and vegetables chain (Table 3), and the second from the food industry (Table 4, which is not shown in this summary). The aim of both case studies was to arrive at functionality demands for (traceability) systems.

Table 3: Important information system functions at a trader of fruit and vegetables

Supply	Storing of purchase specifications Coupling of lot number to supplier data and production data Coupling of lot number to entry control data
Storage	Coupling of lot number to storage location and conditions (e.g. temperature, time)
Assembly	Registration of new lot numbers linked to preceding lot numbers
Packaging/ labelling	Coupling of lot number with label
Sales	Coupling of lot numbers to invoice data Coupling of lot number to distribution data

Benchmark results
In 2002 an international benchmark study was carried out initiated by the Dutch Ministry of Agriculture, Nature Management and Fisheries and the Ministry of Economic Affairs (Van der Vorst et al. 2003). The research aimed at gaining insight into current international practices in food supply chains regarding the use of Information and Communication Technologies (ICT) to support traceability of food products to guarantee food safety.
One of the main conclusions of the research is that the *differences between chains are larger than the differences between countries*, concerning the use of ICT for traceability. The research shows that food supply chains have become global chains. Regulations are different in different parts of the world, but because retailers and processors have become global players the same rules apply for everyone. This paper presents the main results and some best practices.

A selection of the Benchmark results:

- There is a huge *diversity of performance* concerning traceability in the supply chain. In many cases companies still focus on their own business instead of the complete supply chain.
- There are a number of *best practices* that have nearly full traceability in the supply chain. These best practices are usually completely integrated firms or highly coordinated supply chains that comprise feed suppliers, farmers, processing firms and retail concerns, that have agreed on the use of specific standards and systems.
  Most of these best practice chains achieve more than the present legal food safety demands and try to increase their market share and/or margin by distinguishing themselves from competition, hence following the compliance-oriented strategy.
- *Legislation* is an important incentive for companies to comply with traceability demands.
- Most companies *focus on prevention* instead of traceability. Legislation so far gives no clear rules for the required performance of traceability systems (speed of traceability, detail level, etc.). Companies, therefore, focus on GMP, HACCP, ISO, etc. However, these systems provide in-company traceability but no chain traceability.

- There are only *a few ICT applications* specifically designed for traceability. In most cases traceability is established via the linking of existing registration systems destined for other purposes, such as purchasing, production, sales, laboratory, financing, etc. (such as ERP, WMS and LIMS systems). The research also shows that there are only minor differences between ICT applications in different countries.
- When traceability systems are in place, companies cannot always profit fully. When incidents occur, *retailers often remove all articles from the shelves* and not just the articles from the specific lot concerned.

Bottlenecks and success factors

During the research a number of bottlenecks and success factors were identified for full, fast and reliable traceability in food supply chains.
The most important *bottlenecks* that were identified are the following:

- Indefinite and differentiated performance levels concerning traceability resulting in a follow-and-wait policy of actors in the supply chain;
- Little economical incentive: it is unclear what the exact benefits of traceability will be (especially as long as consumers are unwilling to pay more for a traceable product), and it is also unclear what the costs of traceability are;
- High investments in infrastructures for 100% traceability
- Lack of chain organisation and chain transparency;
- Traceability of products in quality assurance schemes is restricted: these schemes are usually focused on parts of the supply chain and not the complete supply chain;
- Lack/difficulties of standardisation: within a chain, within one country as well as between countries;
- Businesses in food supply chains have such specific characteristics that each supply chain has its own specific elements: standardisation is therefore difficult.

In table 7 is an overview of the bottlenecks concerning traceability in four chains: meat, dairy, vegetable & fruit, grain. In this summary, only the part with bottlenecks for the Vegetable & fruit chain is given below:

Table 7: Overview of the bottlenecks concerning traceability in the four chains

Bottlenecks Vegetable & fruit chain	- Traceability is lost at retailers and traders - Unit of traceability is strongly dependent on the packaging (insufficient traceability through auction and stores) - Legislation is organised per link, leading to traceability being unsystematic - Lack of standards for coding - Batches are too small to make traceability cost effective

The most important *success factors* were identified as follows:

- Universal definition of the legally required functionalities of traceability systems in food supply chains and the minimal performance requirements.
- Identification, registering and exchange of data in all links of a supply chain according to a uniform standard and at the same level of detail (tracing unit).
- Implementation of a risk assessment of the supply chain and a focus on the main risks;
- Making the added value of traceability visible to everyone depending on the functionality (product recall, logistical optimisation, etc.).
- Use of a joint approach by all chain participants in the development of a functional and modular basic design for a traceability system that is suitable for a large number of specific situations in food supply chains.
- Making the chain transparent for all actors.

The chapter ends by giving some important questions which are playing a major role in the field of traceability in food supply chains.

Relevancy for the LEI project:

Chapter 10 gives a good representation of the problems that actors in the food chain face if they want to put a traceability system in place. It also gives the success factors, but not the answer how to come to them. This shows that there are a lot of difficulties before the problems round traceability will be solved. An important lesson from this article for the agricultural sector is that there is specific information from their sector, such as the bottlenecks and information system functions given for the vegetable & fruit chain. Having this information, the main job now is to focus on dealing with this information and trying to make traceability work in this sector.

XII. Food authenticity and traceability
Lees M., 2003 (edited)
ISBN: 0 8493 1763 0

This book is about authenticity and traceability of food. The first part of this book deals with analytical techniques applied to food authentication, the second part relates these techniques to particular food and beverage products, and finally the aspect of traceability in food is reviewed.

Chapter 22: Developing traceability systems across the supply chain
By: Furness A. and Osman K.A., p. 473-495

All traceability systems, irrespective of supply chain items or industry, must have common features:

- *Item identification*, unambiguous and linkable for accommodating processing and handling in the supply chain.
- *Item-attendant and/or item-associated information* appropriate to nodal transforms and transactions and any inter-nodal events that have a bearing upon traceability. (A node is distinguished as a point in the chain in which the item is handled or processed in some way).
- *Process-based information* relating and linked to items processed or handled in the supply chain.
- *Communication* links to allow access and change of information.

A significant and widely used system for identification is the EAN.UCC system. At the moment the author was writing this chapter (2003), the EAN.UCC system comprised of six standard numbering structures:
<u>1. Global Trade Item Number (GTIN)</u>
GTIN was formerly known as the Article Number, and is used to identify trade items. The trade item is recognized as any entity, product or service for which there is a need to retrieve pre-defined, item-attendant data at any point within a supply chain. The GTIN is defined as a 14-digit number, from which a family of four unique numbering structures is derived.

<u>2. Serial Shipping Container Code (SSCC)</u>
The SSCC is an 18-digit code, used to identify logistical units e.g. shipping containers or transport units.

<u>3. Global Location Number (GLN)</u>
The GLN provides a unique numbering system for locations. GLN identifies legal entities (e.g. companies, bank), functional entities (specific department within a company, e.g. accounting department) and physical entities (particular room in a building, e.g. delivery point). The identification of locations enables an efficient flow of goods and information between trading partners.

<u>4. Global Returnable Asset Identifier (GRAI)</u>
GRAI has an essentially 14-digits structure and is used to identify re-usable entities which are normally used for the transportation and storage of goods, like containers and boxes.

5. Global Individual Asset Identifier (GIAI)
GIAI is used to uniquely identify an entity that is part of an inventory within a given company. The number can be up to 30-digits in length.

6. Global Service Relation Number (GSRN)
GSRN is an 18-digit code comprising a company code and a service reference to identify the recipient of services form a service provider.

Relevancy for the LEI project:
This chapter gives an overview of the different aspects that have to be taken in consideration when a firm, industry or a specific supply chain is planning to develop a traceability system. Also the explanation of EAN.UCC system is very useful, because this system is globally used and has great potential to become a world-wide, standard traceability system. This chapter is relevant for the agricultural industry because it has a clear structure what to keep in mind when thinking about traceability and can be used as a guide or checklist during this process.

Chapter 25: Safety and traceability of animal feed
By: Notermans S., Beumer H., 519-553

Even in the best managed animal feed production industry, a safety issue of a feedstuff may occur. This is due to rare (chemical, microbiological, physical) hazards that occur which are usually not included in the in GMP are HACCP concept, corrupt practices by involved actors which are forbidden by law, are human failings because of carelessness. Therefore it is important that feed companies have a traceability system, to be able to recall unsafe products out of the distribution chain. The main objective of traceability is to minimize any adverse health effects by a quick and complete recall. One of the first considerations is to define a lot. Ideally a lot is a quantity of feed produced and handled under uniform conditions. In practice this usually means material produced within a limited period of time. The less uniform the conditions of production, the shorter the period of time should be. Under GMP, a lot number is a code that allows identification of the feed in relation to some aspect if production, the kind of formulation, or a time interval in the production schedule. In the commercial sense a lot is a quantity of product supposedly produced from the identical ingredients, processed under the same conditions and usually on a particular production line.

Before implementing a traceability system, feed businesses should first of all define the scope of the traceability that can be achieved. Traceability need to be composed of three elements:

- *Supplier traceability*: traceability of suppliers and their products entering the business in question. Relevant information for example is: name of and supplier, supplier batch code, delivery date, lot number, etc.
- *Process traceability*: traceability of feedstuffs through the supply chain. Important elements in process traceability are e.g. use of a unique batch code identifier, each and every sealable unit in the product batch should be coded, internal documentation should always accompany the product batch etc.
- *Customer traceability*: traceability of feed stuffs to immediate customer. Important elements are e.g. a list of immediate customers which must be updated regularly, container code of transport vehicle, a list of the products being purchased with the details of each product such as product name, batch codes etc.

Difficulties encountered and possible solutions

Animal feed is a very special product, because a clear separation between individual batches of finished feed is not always possible. Below is a selection of the many difficulties and their possible solutions in establishing a traceability system for this product:

- Incase of bulk delivery of ingredients into large storage and production facilities, it may not be possible to ensure that only ingredients from a single batch have been used. The delivery dates, identifications of prior storage facility and weight or volume of the delivery may be the only way of checking this point.
- There are companies of different sizes and varying abilities to implement and maintain a traceability system. For small and medium enterprises, the cost of a traceability system may be greater than the profits. This can be partly avoided by developing common codes of practices for traceability with clear instructions, and standardized computer software.
- The procedures at the different stages of the chain are not well established, e.g. companies are using different control or tracing systems. This problem can be solved by using identical electronic systems for transferring data between links. However this is only possible with good co-operation and clear arrangements.
- Problems arise when the product can not be physically labeled. This applies to dried or liquid bulk products which are common in the feed business. In such cases, accompanying documents are necessary for the identification of the products. It may also be necessary to limit the lot size.
- Mixing and carry-over of products/ingredients. For example the re-use of materials, storage of bulk products in tanks which have not yet been empties, and carry-over of ingredients where there has been no cleaning between the production of different lots. These difficulties are controllable, but they often require a restructuring of a large part of the production facility.

Relevancy for the LEI project:

Although this chapter is about animal feed, it can be very useful for the agricultural sector, because a lot of problems encountered by the animal feed industry are also faced in the agricultural sector. The good thing about this chapter is that there are also possible solutions described for the problems. An important point is that small firms may have more cost than benefits when “individually” implementing a traceability system. Since there are quite a lot of small firms in the agricultural sector, the advice is that the industry or a co-operation of small firms must try to develop a standard traceability system.

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