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Review

Traceability from a European perspective

F. Schwägele *

Institute for Chemistry and Physics, Federal Research Centre for Nutrition and Food–Location Kulmbach, E.-C.-Baumann-Strasse 20, D-95326 Kulmbach, Germany

Abstract

At pan-European level there is a need for traceability systems giving information on origin, processing, retailing and final destination of foodstuffs. Such systems shall enhance consumer confidence in food; enable the regulatory authorities to identify and to withdraw health hazardous and non-consumable foodstuffs from the market. Animal feeds are an element in this "food-to-farm" approach to public health. Such feedstuffs are preliminary elements of some foods for human consumption, and hence are an inherent element of the food chain.

A harmonised pan-European food traceability protocol would greatly assist authorities in detecting fraud as well as dangerous substances. The food chain comprises a range of sequential and parallel stages bridging the full spectrum from agricultural production to the consumable foodstuffs by consumers. EU legislation on traceability and the technologies needed to implement this system for meat and meat products are the focus of this paper.

Keywords: Traceability; Tracking; Meat; Meat products; Food; Feed

Contents

* Tel.: +49 9221 803 216; fax: +49 9221 803 303.
E-mail address: c-schwaegele@baff-kulmbach.de.

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1. Introduction

Until the end of the last year (2004) food and feed business operators had to conform to the traceability directives demanded by their customers along the entire chain. Large retailers in Europe like Aldi, Lidl, Real, Metro, and Marks and Spencer were very rigorous in their criteria for traceability. But as 1 January 2005, the new EU regulations mandate that all food and feed business operators be legally bound to have traceability systems, even when their customers do not require it.

Many food and feed companies still believe that they already have sufficient traceability procedures in place. However, even if that is the case, the problems are hidden in the detail. The new regime impacts hardest the smaller companies, which are not already complying with the traceability requirements of large retail customers.

The General Food Law, i.e., Regulation (EC) 178 (2002) of the European Parliament and the Council published on 28 January 2002

(i) outlines the general principles and requirements of food law,
(ii) establishes the European Food Safety Authority and
(iii) provides procedures in matter of food safety, i.e., among other things the implementation of traceability systems in the food and feed supply chains in Europe.

Article 18 of the regulation referring to traceability is effective since 1 January 2005. The following describes the details of the EU legislation on traceability and summarises possibilities for tracing and tracking of meat and meat products.

2. European legislation on traceability

Article 18 of Regulation (EC) 178 (2002) refers to traceability and consists of five major points:

1. The traceability of food, feed, food-producing animals, and any other substance intended to be, or expected to be, incorporated into a food or feed shall be established at all stages of production, processing and distribution.
2. Food and feed business operators shall be able to identify any person from whom they have been supplied with a food, a feed, a food-producing animal, or any substance intended to be, or expected to be, incorporated into a food or feed. To this end, such operators shall have in place systems and procedures, which allow for this information to be made available to the competent authorities on demand.
3. Food and feed business operators shall have in place systems and procedures to identify the other businesses to which their products have been supplied. This information shall be made available to the competent authorities on demand.
4. Food or feed which is placed on the market or is likely to be placed on the market in the Community shall be adequately labelled or identified to facilitate its traceability, through relevant documentation or information in accordance with the relevant requirements of more specific provisions.
5. Provisions for the purpose of applying the requirements of this Article in respect of specific sectors may be adopted in accordance with the procedure laid down in Article 58, paragraph 2, referring to *Committee and Mediation Procedures*.

In particular, Article 58, paragraph 2 of the above Regulation (EC) 178 (2002) says: Where reference is made to this paragraph, the procedure laid down in Article 5 of Decision (EC) 468 (1999) dealing with regulatory measures shall apply, in compliance with Articles 7 and 8 thereof.

Articles 19 and 20 of Regulation (EC) 178 (2002) cover the responsibilities of food and feed business operators, respectively, and state that, if an operator considers, or has reason to believe that a food/feed which they have imported, produced, processed, manufactured or distributed is not in compliance with the food/feed safety requirement, they will immediately initiate procedures to withdraw the food/feed in question from the market where the food/feed has left the immediate control of that initial food/feed business operator and inform the competent authorities thereof.

2.1. Traceability along the full supply chain

The General Food Law covers the entire supply chain [Regulation (EC) 178 (2002), Article 18, paragraph 1]. In order to be able to trace products and retrieve related information, producers must collect information and

keep track of products during all stages of production (primary production, processing, distribution, retailing, and consumer). Therefore, traceability can be divided into two key functions, tracking and tracing (Fig. 1). Tracking can be defined as the ability to follow the path of an item as it moves downstream through the supply chain from the beginning to the end. Tracing is the ability to identify the origin of an item or group of items, through records, upstream in the supply chain. Methodologies for the analyses of the food and feed materials combined with information technology systems are essential to delivering a working tracking and tracing system.

Previously, it was sufficient for a processor to be able to identify the source of an ingredient; now the processor is obliged to ensure that the food products meet the requirements of food law. This implies that the source of all ingredients can be traced and a processor must therefore be able to prove that his supplier can provide full traceability.

If any problem is suspected, tracking must go as far as the consumer. Traceability applies to everything that contributes to food safety, including packaging, closures, seals, jars, etc. Traceability also covers everything that happens to the products before, during and after the manufacturing, packaging, and distribution. This involves ingredients, processes, test and test results, environment (temperature, time, humidity), resources used (people, machines, knives), transport methods, timescales, etc.

2.2. Implications for food processors

A number of implications exist for food processors, which they will ignore on their peril: more data will have to be recorded on different levels. Who will do this and how will this be done? Data have to be kept for extended periods of time. Therefore, storage and accessibility have to be taken into consideration. Gathered data have to be linked for traceability and have to be highly accurate, as a data error could result in a whole consignment of products being recalled unnecessarily or even lead to a factory shutdown. Data have to be collected and stored quickly. Food processors cannot afford to let data collecting affect their production costs. All of this has to be achieved at the lowest cost possible. Food processors cannot rely on paper records, systems that are not linked together or manual data entry. Automated data logging is the only possible option. Food processors will need integrated traceability data through production, storage, selling and quality control. Systems designed to provide instant trace enquiries through highly integrated traceable data will be required. Food processors must have thoroughly tested proven, infallible systems.

3. Traceability in meat and meat products

There are several technologies available that can detect certain characteristics of (or elements in) foodstuffs derived from animal tissue. Some of these technologies can be used to make definite inferences regarding the foodstuff's origin or history, while others can only be used to confirm the presence of specific components.

With respect to traceability along the full supply chain of meat and meat products the following aspects are of importance. They shall, if possible, give information on animal species, origin, authenticity, age, composition and production system (including feed).

3.1. Species identification – protein, fatty acids and DNA based methods

It is necessary to have reliable methods, which allow a fast and unequivocal identification of animal species. Suitable analytical targets proved to be proteins, DNA or lipids.

3.1.1. Protein based methods

Proteins (enzymes, myoglobin, etc.) have been widely used as species markers. Applicable techniques include separation of water-soluble proteins by starch, polyacrylamide and agarose gel electrophoresis (Cowie, 1968; Mackie, 1980) or isoelectric focusing (IEF) (Hofmann, 1986; Jemmi & Schlosser, 1993). Highly resolved water-soluble protein patterns can be used to

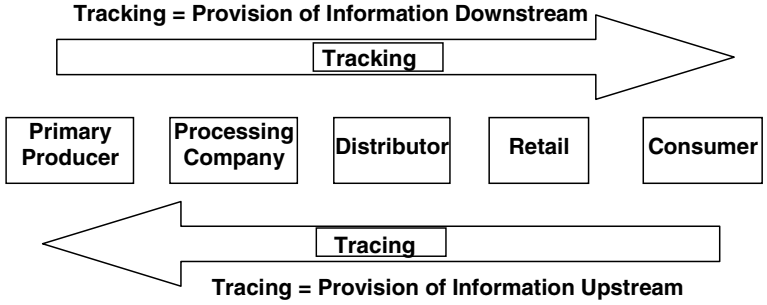

Fig. 1. Tracking and tracing along the food chain.

differentiate genetically close-related species (Hofmann & Blüchel, 1986). The limit of detection of gel electrophoretical methods varies between 0.1% and 1% and depends on the visualisation procedure of the proteins bands.

Immunological techniques like Western-Blotting (Schwägele, 2001) and a specific type of enzyme immuno assay (EIA), the so-called "enzyme linked immuno sorbent assay" (ELISA) (Schwägele, 2001) performed on the solid surface of microwell plates are using suitable target proteins for analysis. A qualitative detection of animal species is possible and the limit of detection depends upon their content in meat products (pork $\leqslant$1%; poultry and beef $\leqslant$2%; sheep $\leqslant$5%).

Proteomics can be used to differentiate species, breeds, and varieties by their specific protein pattern (Meketowa, Abbas-Hawks, Vorhees, & Hadfield, 2003).

3.1.2. Lipid based methods

Lipid components and fatty acids can serve as target substances for animal species identification. The percentage of the composition between saturated, monounsaturated and polyunsaturated fatty acids is a possible animal species marker, which can be determined by means of gas chromatography (GC) or gas chromatography coupled with mass spectroscopy (GC–MS). However, analytical practice shows that this method is tainted with large variations leading to less reliable results in single species identification and furthermore in composed meat products consisting of mixtures of different animal species. (Honikel, Gempel, & Schwägele, 2002).

3.1.3. DNA based methods

In recent years, DNA analytical techniques have been applied to food research and food control. The first DNA tests for species identification in foods were performed using specific DNA probes in hybridisation assays (Chikuni, Ozutsumi, Koishikawa, & Kato, 1990; Wintero, Thomsen, & Davies, 1990). Polymerase chain reaction (PCR) has been developed into a key technology for species identification in foods and feeds (Saiki et al., 1988). PCR-RFLP (restriction fragment length polymorphism) has been used for the species identification of food relevant animals and plants (Meyer, Höfelein, Lüthy, & Candrian (1995); Verkaar, Boutaga, Nijman, & Lenstra, 2001).

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 (Kaemmer, Afza, Weising, Kahl, & Novak, 1992; Rehbein et al., 1999; Weder, 2002). Many species-specific PCR systems have been described for animal and plant species (Altmann, Binke, & Schwägele, 2004; Behrens, Unthan, Brinkmann, Buchholz, & Latus, 1999; Kingombe et al., 2001). These techniques allow for the analysis of very complex samples with high sensitivity (Altmann et al., 2004; Fig. 2). Even in foods that have been produced under severe processing conditions (e.g., sterilisation) DNA techniques are effective. The limit of detection is usually $\leqslant$0.1%, but is dependent upon the PCR method (Schwägele, 2003).

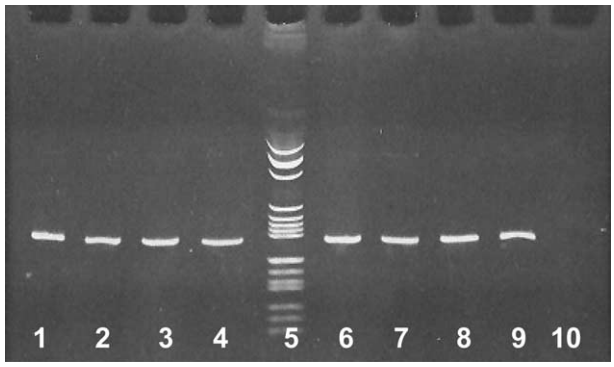

Fig. 2. Electrophoretic analysis of PCR products amplified by means of DNA isolated from goat tissue containing products. Goat specific primer system BC290501 was used for amplification (Altmann et al., 2004). Lanes: (1) Salami; (2) Mini salami; (3) Landjäger; (4) Liver sausage; (5) molecular weight standard (51–587 base pairs); (6) Weißwurst; (7) Gelbwurst; (8) Wiener; (9) Meat loaf; (10) Emulsified type sausage without goat meat consisting of beef, pork, chicken, turkey, duck, horse and sheep.

Species identification and quantification can also be performed using real time PCR (Wurz, Bluth, Zeltz, Pfeifer, & Willmund, 1999). In general, these techniques are more developed and reliable for the quantification of genetically modified organisms (Pöpping, 2001) than for natural animal or plant species (Binke, Altmann, Fischer, Müller, & Schwägele, 2004; Binke, Altmann, & Schwägele, 2003).

DNA sequence information can be used for species identification. The development of modern molecular biology techniques including various sequencing techniques has led to a large number of base sequences. Unfortunately, not all of them are available in the various DNA databases. For species identification, the mitochondrial DNA (mtDNA) is the most widely used target molecule. The main reason to use mtDNA for this kind of analysis is the availability of numerous sequences in databases and the high genetic variability of mtDNA, which allows sophisticated primer design for sequencing. DNA sequencing is theoretically the most informative and precise technique but requires samples consisting only of a single species. Sequencing allows species identification without reference material if the generated sequence is available in a database. The technique also has been named FINS (Forensically Informative Nucleotide Sequencing; Bartlett & Davidson, 1992).

3.2. Authenticity, geographical origin and detection of fraud

To ensure authenticity as well as geographical origin and to detect fraud in the area of meat and meat products the above-mentioned electrophoretic, chromatographic, and molecular biological methods combined with other chemical and physical procedures can be very effectively applied to traceability as noted below.

(i) Protected designation of origin (PDO). PDO covers the term used to describe foodstuffs, which are produced, processed, and prepared in a given geographical area using recognised methodology (e.g., Jamon de Teruel, Parma ham).
(ii) Protected geographical indication (PGI). This geographical link must cover at least one of the stages of production, processing or preparation. Furthermore, the product can benefit from a good reputation (e.g., Schwarzwälder Schinken, Nürnberger Bratwürste, Thüringer Rostbratwürste).
(iii) Certificate of Specific Character (CSC). CSC means recognition of all member states of the EU that a foodstuff possesses specific characteristics, which distinguish it clearly from similar products in the same category (e.g., Münchner Weißwurst, Salami Milanese).

3.2.1. NMR and MS based methods

Authentication strategies involving the use of multi-isotopic parameters (^{2}H, ^{13}C, ^{15}N, ^{18}O, ^{34}S and ^{87}Sr) facilitated by increasingly rapid measurement procedures present a complex analytical challenge because of many compounding factors, such as imported feed, origin of animal tissue, and metabolic turnover of tissue-specific substances.

Stable isotope analyses are considered an excellent tool for origin assessment. The ratio $^{13}C/^{12}C$ gives straightforward responses concerning the primary photosynthetic metabolism of feed plants (O'Leary, 1981), and the ratios of the stable isotopes of oxygen ($^{16}O/^{18}O$) and hydrogen ($^{2}H/^{1}H$) are good indicators of environmental conditions, e.g., H_2O (Ziegler, Osmond, Stichler, & Trimborn, 1976) and enables the tracing of the origin of animal material. The two main techniques used to determine the isotope ratios of natural products are isotope ratio mass spectrometry (IRMS) and site-specific natural isotope fractionation from nuclear magnetic resonance (SNIF–NMR). NMR has the advantage over IRMS in that the natural abundance of ^{2}H isotopomers may be precisely identified in compounds and accurately quantified by SNIF–NMR (Martin & Martin, 1991), whereas IRMS only gives a mean value of the deuterium content of a given chemical species.

Both low and high resolution NMR can be used for the detection of plant species and genetically modified plant or animal material in food, but specific marker components must be isolated prior to analysis.

The geographic origin of a foodstuff can affect its composition and associated food-borne risks to the "food-to-farm" chain. Also, less expensive ingredients or components of dubious geographical origin may be fraudulently included for monetary gain. A need exists to develop a protocol enabling a foodstuff's geographic origin to be assessed. Techniques can be used to "fingerprint" the geographic origins of certain plant and animal materials; and these methodologies can form part of a suite of traceability tests (Polychroniadou & Vafopoulou, 1985). Geographical effects arise due to differences in the geological origin of the soils, soil pH, anthropogenic contaminants, atmospheric and climatic differences, and the interaction among certain trace elements. Zoonoses risks can vary considerably from one country to another (e.g., BSE risk in UK≫USA). Trace element analysis by inductively coupled plasma mass spectroscopy (ICP-MS) has been used to determine the geographic origin of soils, plants and fruit (Anderson, Magnuson, Tschirgi, & Smith, 1999). Trace element signatures can be used to identify the geographical provenance of a sample because organisms accumulate in their tissues, from the water, food and air, the elements available from the environment where they live. Differences in the isotope distributions of these trace elements among different geographical locations give different "signatures" of isotopes in the organic tissues.

GC–MS and liquid chromatography in combination with mass spectroscopy (LC–MS) have been successfully applied to the analysis of organic contaminants (PCBs, Dioxins, etc) in the origin of various feed and food materials.

3.2.2. 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. Gonzalez-Martin, Gonzalez-Perez, and Hernandez-Mendez (2002) successfully applied NIR to the determination of the concentrations of Fe, Ca, Na and K in pork. Pires, Lemos, and Kessler (2001) demonstrated the potential of NIR to measure the concentration of 11 vitamin levels in poultry feeds. Garnsworthy, Wiseman, and Fegeros (2000) reported the application of NIR to the prediction of chemical, nutritive, and agronomic characteristics of wheat.

Isaksson, Nilsen, Togersen, Hammond, and Hildrum (1996) analysed the composition of different raw meat products and reported successful application of NIR spectroscopy to the determination of fat, moisture and protein. However, determination of carbohydrate levels was not satisfactory. Cozzolino, Mattos, and Martins (2002) used NIR reflectance to distinguish between beef muscle according to the feeding systems used in production.

Al-Jowder, Kemsley, and Wilson (2002) employed MIR to discriminate between pure beef and beef containing 20% w/w of a range of potential adulterants (heart, tripe, kidney, and liver). McElhinney, Downey, and O'Donnell (1999) demonstrated the use of NIR and MIR spectroscopy for species identification in raw homogenised meat samples.

3.3. Traceability of production process and storage

To determine the "history of meat and meat products" with respect to the production processes and changes occurring during storage, a number of technologies (DNA based methods; electrophoresis including capillary electrophoresis [CE]; immunological methods; high pressure liquid chromatography [HPLC including HPLC–MS]; lipid based methods [GC, GC–MS, and GC × GC–MS]; IR and NMR spectroscopy; electron microscopy) can be used.

One of the most important but widely unresolved issues in food traceability is to quantify the degree of batch mixing associated with a given blend of raw materials. There is a need for considerable research designed to address this issue.

The reliable use of "tracer substances" has to be investigated since they can be used to augment details concerning batch mixing (e.g., detection of enzyme activities and proteomics serving as indicators for the degree of sterilisation.). Tracers can be endogenous (i.e., compounds present in the food due to its make up or processing history) or purposely added to facilitate detection. However, adding tracers needs to be carefully considered as the tracer must not be harmful to the end users and must comply with all legislative requirements. For example, endogenous tracers can be used for fermented, Hungarian style salami, where possible tracer techniques include testing for lipid degradation, lactic acid or volatile components that occur during the ripening process. In addition, holistic (i.e., measuring nearly all compounds) analysis of all compounds in food (metabolites and proteins) and multivariate statistics can be used to characterise food. Characteristic metabolite profiles of foodstuffs can be obtained by holistic analytical methods (GC–MS, LC–MS, and NMR). Bioinformatics can be used to develop models and identify clusters of compounds correlating with certain production methods (organic processing, conservation, etc.) and ingredients. This would allow the identification of new (endogenous) markers for the production methods, origin and others. If methods and tools developed especially for metabolite analysis are available other natural tracers, such as specific isotopes, are not necessary for this purpose. The same strategy could be applied to proteins using techniques and tools developed for proteomics.

In many cases it is possible to infer the degree of sterilisation through certain indicators, such as the degree of protein degradation or the degradation of a marker added to the material prior to the sterilisation step. The addition of tracers is a very powerful adjunct to normal traceability techniques.

Isaksson, Ellekjaer, and Hildrum (1989) and Ellekjaer and Isaksson (1992) concluded that NIR could be used for determination of heat treatments in the temperature range 50–85 °C with an associated prediction error of 2.0–2.1 K. Thyholt, Enersen, and Isaksson (1998) described the use of NIR reflectance spectroscopy to determine endpoint temperature in previously heated beef.

Despite the high costs and consumer concerns, the number and quantity of foods being irradiated is increasing steadily. Currently about 250,000 tonnes of food are irradiated annually. In the USA and Europe, it is a requirement that irradiated food products must be labelled. However, monitoring programs are in place in only a few European countries.

One of the significant challenges to identify irradiated food products is the different techniques necessary to cover the entire spectrum of products. Typical methods used include immunological methods, comet assay, photon-stimulated luminescence, thermoluminescence, and electron spin resonance. However, only a limited number of laboratories worldwide have the necessary capability for the reliable determination of food irradiation.

3.4. Cross-contamination or carry over in food and feed

In several food production facilities, ingredients or raw materials are used that are known to have allergenic properties in human, e.g., milk and egg proteins. Subsequent processing of products using the machines or transport facilities previously used for allergen containing products, may lead to cross-contamination of allergens to products not intended to contain these allergens. Manufacturers of food products should therefore have a high awareness of the risks of cross-contamination of allergenic proteins during the production process of their products. Knowledge of threshold levels for sensitive patients, the use of specific ingredients, cleaning strategies, etc. is helpful to reduce unwanted contamination of allergens. This information can be used to identify (within a given level of tolerance) the critical control points during processing and the aspects to be monitored for the most effective tracking information to be generated.

The same considerations apply to the manufacture of animal feeds formulated to contain antibiotics, coccidiostatica and similar components. If these feed-mixing facilities are used to make feed without antibiotics, cross-contamination is a distinct possibility and appropriate controls are essential.

3.5. Application of biosensors

Immunosensors, based on the antibody antigen recognition, are rapid, simple and sensitive methods that have been developed for the measurement of a wide range of target compounds such as bacteria (*Yersinia pestis*), alphatoxin, ricin, brevetoxin, okadaic acid (Vaughan, Geary, Pravda, & Guilbault, 2003), pesticide such as atrazine (Schipper, Rauchalles, Kooyman, Hock, & Greve, 1998) and veterinary drug residues (Baxter, O'Connor, Haughey, Crooks, & Elliott, 1999). These techniques offer considerable potential for traceability within the full food chain.

The aim of immunosensors is to develop a system capable of performing a single point determination without calibration between each measurement. Various transduction systems, based on potentiometry (Khomutov, Zherdev, Dzantiev, & Reshetilov, 1994), electrochemiluminescence (Marquette, Coulet, & Blum, 1999) and chemiluminescence (Samsonova, Baxter, Crooks, Small, & Elliott, 2001) have been used successfully.

Biosensors basically have two components, biological or sensor molecules and a signal transducer. The biological component consists of an antigen or antibody. The transducer detects the change in one or more physicochemical property of the biological molecule. Increasing attention is being paid to the development of immunobiosensors especially to assay clinical samples. This technology uses novel biosensor techniques which can combine very specific antibody–antigen interaction with very sensitive signal transduction to enable faster, more sensitive and reliable techniques, which can also be applied to routine monitoring and quality control protocols in the food chain.

The most commonly used biosensors are the piezo electric (PZ) crystal, where the PZ crystal oscillator can be used as a microbalance to detect a change in mass of the crystal due to the formation of antigen–antibody complex, thus permitting it to be utilised as an immunobiosensor. These have been used for typing of the foot and mouth disease virus (Gajendragad, Kamath, Anil, Prabhudas, & Natarajan, 2001). Immunoelectrode and optic fibre biosensors have been used for the detection of Ivermectin in animal carcasses (Samsonova et al., 2001).

3.6. Tracking technology

Electronic data management (Automatic Identification and Data Capture [AIDC]) plays an important role in improving operational efficiency and accuracy of information handling in the "food-to-farm" chain. Since there are no industry standards for handling electronic date through out the complete food chain, the use of the European Article Numbering Association codes (EAN-UCC, 2002) is proposed to improve data tracking. For successful operation of this technology, the environment in which it operates must be relatively clean and this is not always achievable on the farm.

Technologies such as RFID (Radio Frequency IDentification) overcome this problem by using radio signals instead of line of sight for identification, and can be integrated into a prototype recording system. However, product identifiers (tags) are not currently in widespread use, and are expensive in comparison to the barcode. Matrix codes are 2D, but information is stored by blanking out areas of a defined array, rather than in bars. These codes are generally only used in specialist applications, including the marking of very small components. Scanners can operate with a 90% success rate where contamination levels are kept below 10% and barcodes are kept clean and undamaged. The performance of the laser scanner is such that any level of contamination will substantially reduce read success rate. Studies undertaken by Watts, Miller, and Godwin (2003) indicate that the RFID achieve successful reads over 98% of the time, with unprotected and reused tags.

In electronic tracking and tracing systems, 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. The system uniquely identifies products, locations, services and assets and also includes a series of standard data structures known as Application Identifiers (AIs), which allow secondary information about a product such as batch, expiry and lot number to be encoded.

The EAN-UCC (2002) system consists of three components:

(i) Identification numbers – used to identify a product, location, logistic unit, service or asset.
(ii) Data carriers – the barcodes or radio frequency tags used to represent these numbers. The data carriers vary according to the level of information required or the space available. For space-constrained products, the use of reduced space symbology (RSS) barcode is ideal. For traceability purposes, an EAN 128 barcode is used to encode the identification and supplementary information relating to an item.
(iii) Electronic messages – the means of connecting the physical flow of goods with the electronic flow of information. These technologies have been used in meat traceability, providing a robust tracking system for most elements of the meat chain (Harmonised Electronic Data Interchange, HEDI). Such electronic tracking systems play a key role in food labelling.

3.7. Computer modelling and risk assessment

Computer modelling can be a powerful tool to estimate the contamination and transmission pathways for pathogens and food contaminants. It can also help assess the reliability and accuracy of a decision tree, composed of a suite of test pathways. Many epidemiological parameters have been estimated using models where direct measurement is almost impossible (Anderson et al., 1996). 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. For example, work by Anderson et al. (1996) has been significant in the formulation of BSE and prion (Prusiner, 1997) control strategies and policy within the European Union and the calculation of risk in terms of the human consumption of contaminated meat and meat products. Any food traceability system requires associated risk assessment models in order to evaluate the potential health risks to humans and animals (Ferguson, Donnelly, Woolhouse, & Anderson, 1997). Stark, Boyd, and Mousing (2002) illustrated how available information can be organised systematically within a risk model and a quantitative decision support can be provided quickly making optimal use of all available information. Risk assessment methodologies are being used increasingly to quantitatively assess risks to human health imposed by the food chain (Jordan, McEwen, Lammerding, McNab, & Wilson, 1999).

4. Conclusions

Regulation (EC) 178 (2002):

(i) stipulates that the delivery of safe food and animal feed belongs to specific food and feed producers,
(ii) specifies that foodstuffs, animal feed and feed ingredients must be traceable,
(iii) includes clear procedures for developing food law and dealing with emergencies,
(iv) gives the European Commission new powers to take emergency measures when national authorities are unable to contain an emerging food risk,
(v) establishes the "Standing Committee on the Food Chain and Animal Health, in the place of three Standing Committees", bringing together Member States representatives with important roles in decision-making on food safety issues.

In the area of meat and meat products, there is a need for fast and reliable systems to enable traceability along the full chain to provide safe and high quality food for the consumer with respect to origin and processing. Traceability cannot only be considered as a request of the legislation addressed to the food business operators (primary production, processing, distribution, retailing, and consumer); moreover, it has to be their very own interest in terms of product liability to find practicable ways to implement the new regulation. Within the 5th and 6th framework program, the European Commission has funded various research and development projects such as [ENOSEFOODMICRODETECT (2003); ENTRANSFOOD (2003); MOLSPEC-ID (2004); QUALITYLOWINPUTFOOD (2005)] dealing with traceability along the food chain.

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