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Traceability and quality assurance systems in food supply chains

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Abstract

Purpose of the review: Over the past 5 years, numerous regulations have been drawn up and implemented, which have had a direct impact on food sale from very small and medium-sized enterprises, as well as between countries. These activities require continuous monitoring by inspection agencies on trade policy, safety and risks analysis, with stringent management practices and precaution readiness for emergencies. Food safety, quality, claim validity and proof-of-origin are important for fresh produce, both for clients and customers locally or abroad. As a result, various governmental inspection services and third-party certification agencies are available for regulating the export and import of food commodities. Today, we are facing globalisation of our food-supply chains. This article focuses on better understanding and defining food quality, entities and system components. New tools to identify failure mode and efficiency in processes, as well as practical cases of traceability are referenced and under validation.

Directions for future research: Improving technological skills and competency, as well as training in engineering, applied science and technology, computer technology, economics and logistics must become high priority in relation to food quality, safety, and failure analysis on systems relevant to traceability domains. Very little or no benchmarking is performed or accessible to the industry. More research and adaptation is needed on modelling entity-relation and quality, in combination with sensors and advanced computing. Setting up interactive associations on traceability, computer science, economics, efficient logistics, as well as sharing on a common hub, expertise and problematic cases would speed up international efforts to produce and trade safe produce. Creating and making automatic identification and data capture information technology available at regional and national centres, where producers, processors, distributors and inspection agencies would bring in or improve confidence levels and, secure access to data, know-how, and practical training and advice is of utmost importance. These are challenging prospects for all parties involved in agri-food safety.

Keywords: fresh produce; quality assurance; traceability; terminology; definitions; managing tools; guidelines; standards; pervasive technology; sensors; modelling; case applications

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Abbreviations

ABN	Adaptive Business Network
AIDC	Automatic Identification and Data Collection
AFNOR	Agence Française de Normalisation
BC	Bar Code/Bar Coding
CBA	Cost Benefit Analysis
CPMA	Canadian Produce Marketing Association
EAN	European Article Number
EAN-UCC	European Article Numbering - Uniform Code Council
EAN International	Based in Brussels. Is a member organisation that jointly manages EAN. UCC system with UCC
EDI	Electronic Data Interchange
EC	European Community
EU	European Union
FMEA	Failure Modes and Effects Analysis
FMECA	Failure Modes, Effects and Criticality Analysis
GAP	Good Agriculture Practice
GLP	Good Laboratory Practice

GMO	Genetically Modified Organism
GMP	Good Manufacturing Practice
GS1	Global Standard 1, a worldwide organisation
GTIN	Global Trade Item Number
HACCP	Hazard Analysis and Critical Control Point, now under a new standard ISO-22000 (2005)
IRMS	Isotope Ratios Mass Spectrometry
LIMS	Laboratory Information Management System
MS	Mass Spectrometry
PDA	Personal Digital Assistance
PMA	Produce Marketing Association
RFID	Radiofrequency Identification
ROI	Return-On-Investment
RSS	Reduced Space Symbology
SPECT	Single Photon Emission Computerised Tomography
SSCC	Serial Shipping Container Code
TRU	Traceable Resource Unit
UCC	Uniform Code Council
XML	Extensible Mark up Language

Terminology

Activity Specific pursuit in which a person partakes. Also, a function to be performed; a piece of work that one must do (Task); an organizational unit for performing a specific function.

Entity An item that can be individually described and considered ie, an activity, a process, processes (eg, how we do activity), a product, an organisation, a system, a person or any combination thereof.

Ishikawa/ Fishbone diagram As the inventor of the tool, K. Ishikawa used his technique effectively in the 1960's. This is a Cause-and-Effect diagram where the basic problems or quality interest are on the left on a fishbone like distribution and the main effect on extreme right of the central bone. The main categories are the Methods, the Man-power, the Management, the Material, the Equipment-machine, Space-environment. Also, very similar to the CEDAC principles (Cause and Effect Diagram and Cards) where cards and statistical control where added up, in the USA [1]. In Europe, the "Méthode 5M"[2] is recognised.

ISO-8402 Quality Management and Quality Assurance containing the Vocabulary (1994), the generally recognised and of current use and some definitions.

Logistic Ensemble of tasks, activities that converge to bring order to physical flows within an enterprise, i.e. raw materials, various components, fabrication, operational research…It includes the purchase, stock handling, storage, client recalls, sales, administrative tasks and quality management as well as information fluxes.

Lot Ensemble of units of the same reference that is decided to be produced, manufactured and consecutively under identical conditions. Or, the material just bought, that can referenced, with the specifications and purchasing order. Other definitions exist.

Organisation A company, corporation, firm or institution, which can be public or private.

Pareto Diagram The Pareto diagram is used to determine what characteristics are major contributors in a process. This task is to construct by ranking the data in frequency of occurrence and plotting the bars in descending order. A cumulative line could be added. A rule of 80/20 can be established or ``vital few and trivial too many``. This tool is used for quality management, for QA Department and impact on returns, recalls size and rejects cost *per se*.

Pervasive Technology / Ubiquitous Computing Pervasive computing is the trend towards increasing ubiquitous computing devices in the environment brought about by convergence of interactions between advanced electronic, portable devices, wireless technology and the internet. Pervasive or ubiquitous computing within the context of the Adaptive Business Network is more than the ability to access information virtually anywhere and at any time. It provides the ability to sense and respond more quickly to changing markets.

PLU Price look-up. Refers to the International Federation for Produce coding for fresh fruits and vegetables, and is a very small sticker on the produce or tag unit.

Procedure A specified way of performing an activity. In many cases, procedures are documented ie, quality system procedure. It contains the purpose, the scope of an activity; what will be done, by whom, when, where and how.

Process A set of inter-related resources and activities that transform inputs into outputs. Resources can include personnel, finance, facilities, equipment, techniques and methods.

Product The result of activities or processes including service, hardware, processed material and software or a combination thereof. Also, intangible form as knowledge or concepts.

QA Quality Assurance. All the planned and systematic activities implemented within the quality system.

QC Operational techniques and activities that are used to fulfil requirements for quality (to achieve economical effectiveness).

QP Quality Policy. Overall intentions and demonstration of an organisation with regards to quality, as formally expressed by top management.

Quality The totality of characteristics has an entity, that bear on its ability to satisfy stated or implied needs.

RA Risk Assesment. The estimation of the severity and likelihood or damage from exposure to hazardous agents or situations (Codex Alimentarius 1995: CxCa-95/8). A scientifically-based process consisting of hazard identification, characterisation, and exposure and risk characterisation (Codex Alimentarius 1996: Alinorm 97/13A. Appendix II).

Record A document that presents objective evidence of activities performed or results achieved. Can be hand written, paper format or electronic medium.

Risk The probability of unpleasant event occurring.

Total Traceability Combines the proximity, minimum one step backward and step forward, plus, ascending and descending complete elements. So, one can determine his surface of influence or limits of traceability in the food chain. This is relevant to one particular company. With proper technologies, identification, data collection, mastering flux of products and information, partnership of quality, finally, with know-how one shall have a functional traceability system.

TQM Total Quality Management is a management approach of organisation, centred on quality, based on the participation of all members (employees), long term success of costumer satisfaction and benefits to the society. Also, ensuring growth, customer requirements, staff implication and welfare, market change driven and environmental concern.

Traceability : Proximity / Internal Ability to use mass balance and time stamp on continuous or controlled batches. With material resource/replenishment/replacement planning and enterprise resource planning (material resource / requirement / replenishment planning and enterprise resource planning, respectively) measure the state of optimisation, over production or underproduction

Traceability : Proximity / Internal	states. It can use statistical probability of, in that time frame, on that machine, that lot. Provide information on quality, rework, in coming recall lot, etc. Rapid information on no mixtures of lots and, no breakage in trace/links happened.
Traceability: Ascending / Upstream	Ability to find all steps for a given lot of finished product; the complete history up and down to the origin of all raw materials/ingredients. Often called *trace* or *tracing back.*
Traceability: Descending / Downstream	Ability to retrieve all steps for a given lot of finished product; the complete industrial and its global distribution from its fabrication. Often called *track* or *tracking.*

Introduction

The quality of ingredients (fresh or processed food, consumed or preserved) distributed or traded at local, national and international levels must be nutritious and safe, and meet the appropriate specifications for composition based on national and international standards. Different clients and customers expect implicit or explicit quality characteristics. Products or services are then accepted (1) or rejected (0) according to the equation below:

Accept / reject = function (value * quality * price) …(1)

Potential clients give estimates of what they want or expect to pay for an offer, and whether or not it satisfies their needs in relation to the cost of the product or service. The answer is a matter of perception or measure of real variable attributes within specifications, which is sometimes difficult to establish.

To be successful, very small and medium-sized enterprises generally face five challenges. They have to:

1. master the *acquisition and management of the information* ie, research of…, analyses of…, synthesis of…, proper utilisation of...
2. master *knowledge of the demands* now and in the future ie, clients and their perceptions and their views on quality, perception versus real facts, and their new product-demands.
3. master *conception capacity* ie, means of …, project management, value added analysis, ergonomics, safety and design new products and processes.
4. master *production and organisation skills* ie, human psychosocial management, planning and scheduling skills, quality and safety management information skills, regulation awareness and public relations.
5. *understand and master the integrated food supply chain* ie, pre- and post-plant efficiency, logistics and traceability of necessary information, relevant automated data collection, databases to facilitate rapid response to recall or security threats (ie, knowledge and impact of regulatory laws locally and abroad).

In most companies, business situations arise occasionally and are seen as either new risks, threats or events from which new opportunities for partnership can be generated. As a result, new opportunities need to be identified and prioritised by type, frequency of occurrence and level of monitoring, with consideration given to any readiness actions that might be necessary. Can those risks be transformed into new high-value opportunities? The 10 most encountered reasons for poor quality assurance, poor logistics and poor traceability of entities are concerned for:

- personal safety and well-being of employees
- the company's reputation, products, market (identity preservation) and enterprise competitiveness
- the supply chain, production, purchasing power, processing capacity and capability, total overseas distribution chain
- quality assurance (QA) and monitoring systems ie, hazard analysis and critical control point (HACCP), good manufacturing practice (GMP), traceability and communication (database and telecommunication)
- liability and financial limits
- regulatory compliance and policy impact levels
- loss of scientific, technological, innovative and intellectual properties
- loss of personal, scientific independence, as well as territorial and cross-cultural integrated autonomy
- deterioration of the environment, public health and for animals, plants and the environment including air, water and soil
- the country to lose "brand recognition" and global the perception of high quality and safety of foods (including its institutions and public services)

Today's QA departments are involved in research, development and adaptation, the adoption of HACCP principles and the setting up traceability tools, databases and detailing procedures etc for clients, regional and federal inspection agencies, certification purposes, or to provide proof documents for exports. Traditional data entry into a computer or hand-held assistant involves collecting data on sheets of paper and draft version reports, and manually keying the information into each system. Unfortunately, data entered this way has an error prone ratio of 1:300 characters, so double verification and automation of the collection of data, with proper identifiers and tags, is required for any automated system.

This article reviews the fundamentals of quality assurance terminology, system and discusses new tools to evaluate the risk of failure of quality traceability systems in supply chains.

Quality assurance, GMP, HACCP, food safety, audit, risks and certification

The first consideration for management of quality in the food chain is the fundamental of QA, which includes product evaluation and specification [1**]. Secondly, thought should be given to material and information flux [2**], with the ultimate goal of adopting HACCP principles for achieving industrial safety. Thirdly, individuals should understand the fundamentals of quality systems. Daguisé [3**] presents the image of a professional "Qualitician" who helps to discuss basic knowledge and expertise, which helps to clarify confusions about terminology. This individual is identified as a professional who evolves with new industrial needs of the company. A more holistic description of the complexity of total quality management (TQM) is offered by Rose [4**] and is useful for the unfamiliar reader.

The importance of quality and safety in the food chain is widely understood today. As a result, a vast amount of information on QA, HACCP systems, traceability and the best ways to ensure food quality are available in literature, as well as governmental organisations. Knight *et al.* [5**] describe the many interactions between various organisations whose technical support encompasses different sectors of the food chain in the UK. Quality concepts such as attributes, specifications, and the role of auditing and legislations are highlighted, with an introduction to the Codex Alimentarius. Lahellec [6**] discusses the food safety crisis preoccupation in Europe, agency expertise, risks evaluation and preventions tools. In addition, details of certification and disposition of different levels of the food chain are provided. The role of traceability as a tool, as well as associations involved in crisis prevention are also discussed.

Gehlkopf [7**] reviews the role of the British Retailers Consortium in consumer security. The Consortium presents its recommendations based on HACCP and traceability principles and require certification with qualitative data and nonconformity detection. A final grade or score will impact on audit frequency. Initiatives using preventative measures to assure food safety are underway in Canada [8**], and on-farm HACCP-based programs [9**] have started with 29 commodities. The United States Department of Agriculture (USDA) published a new draft "Guidance for Industry" [10**] in March 2006, which is aimed at minimising the microbial food safety hazard of fresh-cut fruits and vegetables. This document also highlights HACCP and traceability approaches. In addition, the Foodborne Illness Education Information Center [11**] contains on its website product information and educational material, and links produce to more than 30 government and non-governmental sites. HACCP verification and validation, as well as some advances in technology are discussed by Gombas and Stevenson [12**]. An excellent section on audits and verification is presented.

On-farm strategies for farm and quality assurance were gradually introduced into the Scottish Agri-Food industry in the 1990s [13**]. This system is based on the European system of third party certification in which schemes must be accredited and certified on various commodities. Thus, a traceability approach is targeted. In 1998, the objective of using food tracking software was to develop and bring to market a common means of communicating food safety and quality information. The technology developed was the TCP/IP-internet. An interesting approach was generated by Wilson and Clark [14**] in which the internet is used to deliver traceability.

Jonker *et al.* [15**] studied the compliance of suppliers from developing countries with Japan's Food Safety and Quality Standards. Regulations and their enforcement in Japan are reviewed, as well as the private sector's view on standards. Problems and experiences with various commodities and suppliers are discussed and suggestions for improving compliance are formulated. The results of this study highlight the rapid evolution of technology in the last few years, and demonstrate the importance of traceability for ensuring food safety. For example, the quality certification process of the Martinican pineapple industry is being reengineered with food quality and traceability goals [16**] aimed at increasing the confidence of international markets. Similarly, De Sousa and Waters [17**] reviewed quality assurance programs in Europe, Africa, Chile and the UK, and examined their impact across the sector. These authors also found that there were vast developments across the sector in all countries and several initiatives are underway to improve accountability systems.

A framework for Good Agricultural Practice (GAP) on-farm with best practice for the horticultural produce was discussed in the Euro-Retailer Produce Working Group Good Agricultural Practices protocol for fresh fruits and vegetables [18**]. This document discussed traceability in great detail. More recently, Snoekx *et al.* [19**] published a model for predicting quality evolution of horticultural produce in supply chains. They described how the information is created and handled and showed that quality and traceability of tomato can be linked to proper monitoring. Tapia and Welti-Chanes [20**] demonstrated that GMP, HACCP, risk assessment and predictive microbiology approaches for minimally processed fruits and vegetables can have positive impacts on the qualitative control of potential hazards.

Quality manipulation, quality control monitoring and product-climate interactions have been studied by Nicolaï *et al.* [21**]. The authors evaluated logging temperature and humidity, gas composition, chlorophyll fluorescence, fruit resonance frequency, tracing systems, and packing and surface treatments as new technologies for quality monitoring of fruits and vegetables. The new Dutch Food Authority in the Netherlands is in the process of establishing a single organisation to coordinate and direct food policy, research, monitoring and inspection, as well as to communicate with the public on food safety matters. The Food Standards Agency should also be hosted under this new Authority [22**] and is expected to improve consumer confidence in food safety .

With respect to the auditing process and food standards, Dillon and Dillon [23**] describe what the current standards are, why we need them, and discusses the principles outlining the standard-setting process and legal enforcement. The article also mentions various agencies responsible for setting up standards and discusses the need for auditing in food quality assurance.

McEachern *et al.* [24**] introduced the role of regulatory verification of safety and quality control systems in the food industry. This article discusses the shared role between government and industry to achieve a safe and wholesome food supply. Traditional inspections versus system approaches are explained, with supporting examples from the Canadian approach to food inspection. The authors note that the objective of internal integration of government inspection programmes will lead to integrated inspection services based on better, uniform and disciplined inspection strategies, and provide an effective and efficient inspection system that is open and transparent.

A schematic is shown in Figure 1 to demonstrate the various elements of the entity-quality-attribute relationship within an enterprise. It is also important to better understand the use of mass balance of raw materials, ingredients and product units on farms in the manufacturing process, or anywhere in food chain locations (Figure 2).

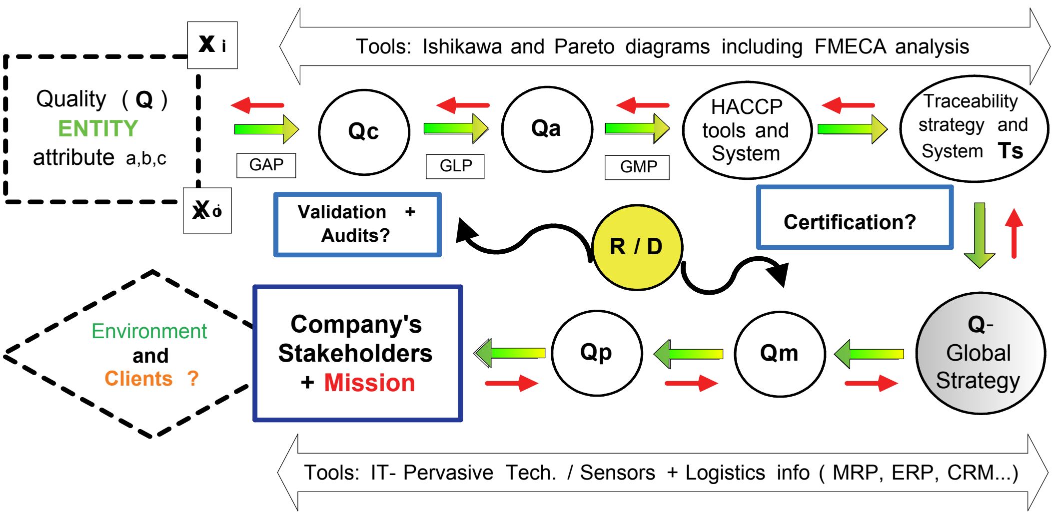
Computer modelling

This section examines the use of entity-relation-quality to generate data for optimum database development and interaction with identifiers using automatic, new adaptive, pervasive technology, as well as e-language ie, extensible mark up language (XML) and electronic data interchange (EDI).

Mapping pipfruit and kiwifruit quality in Australia and New-Zealand using supply chain information [25**] demonstrated the basic tools of GMP with product quality attributes using electronic tags, near infrared for Brix and dry matter, and geographical information. Results of combined technologies are promising for orchard fruit mapping, and are important for traceability proof. Apple production monitoring and data modelling to design databases for producer organisations are described by Habib *et al.* [26**]. This model refers to information set at the plot or the level, including yield, fruit size and quality. This model allows one to trace fruits from individual or commercial lots at the producer organisation level. The history of the orchard is also important. Their semantic structure of information is based on an "entity-relationship" approach, and their resulting conceptual models constitute the basic partner in the design of database structures for fruit production in Southern France.

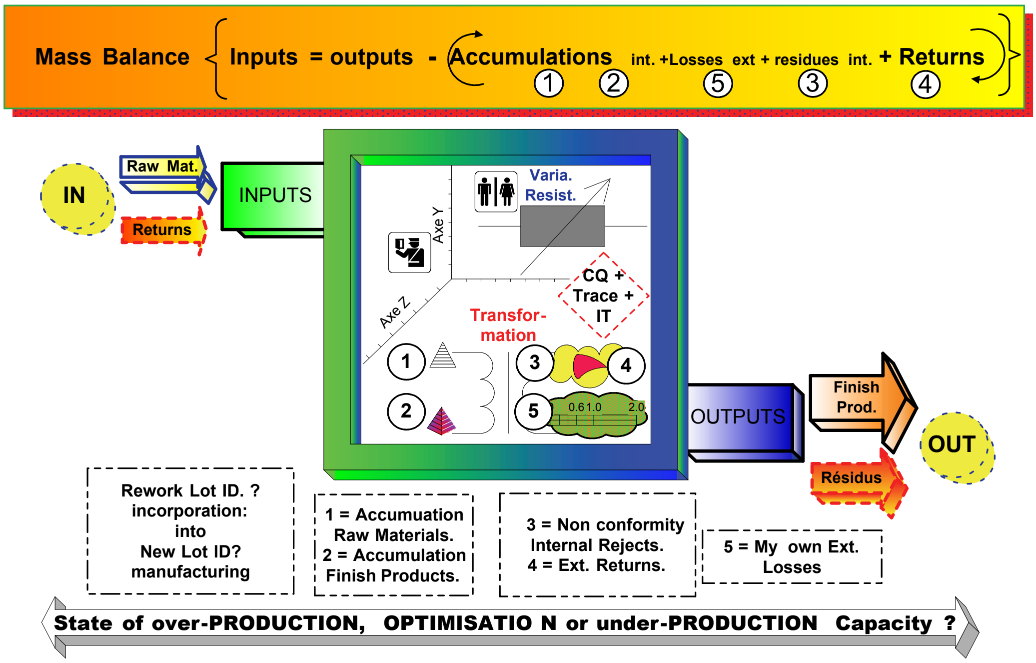
Jansen-Vullers *et al.* [27**] presented an approach to design information systems for traceability of food based on Gazinto graph modelling of goods flow ie, from raw materials to end product. Graphical data were translated into a reference data model that became the foundation for designing the information system. The bill of each lot provided the necessary information for determining the composition of an item based on component items. The system can be used to recall items or certify product quality, and its capacity to adjust the production process to obtain optimisation is very important.

Figure 1. Schematic of various elements of entity quality attributes within an enterprise.



Abbreviations: FMECA, failure modes and effects analysis; HACCP, hazard analysis and critical control point; GAP, good agriculture practice; GLP, good laboratory practice; GMP, good manufacturing practice; Qa, quality assurance; Qc, quality control; Qm, quality management; Qp, quality policy; R/D, research and development; Ts, traceability system

Figure 2. Schematic of mass balance understanding for calculation, and its importance for manufacturing rework, new lot identification and record tracing.



Abbreviations: CQ, control of quality; ext, external; int, internal; IT, information technology; Mat, material; Varia Resist; variable resistance

van Dorp [28**] presented a reference-data model for tracking, tracing and establishing functionality within a system. Three questions on reference models were targeted: 1) what are the expected advantages of using reference models? 2) Which examples can be obtained? and 3) which elements of reference models should be focused on? The research challenges and approaches were delimited. Four reference-data models were constructed and elaborated on. Cases were based on a slaughter facility, a food processor, a leather producer and a pharmaceutical manufacturer. The models successfully allow registration of historic relations between lots and batches, registration of operations on lots and batches, registration of associated operational variables and values, and the registration of capacity units on which operations were executed. From the industrial models, a reference-data model was constructed with success.

Raynaud *et al.* [29**] compared governance of supply chains when private brand ensured quality in chains and where official certifications assured product quality for customers. The study was conducted in seven European countries on a set of 42 cases studies in the agri-food sector; processed meats, cheese, fruits and vegetables. It was concluded that the relationship between quality enforcement mechanisms used in transaction with consumers and the governance of the vertical chains are different. Following a transaction cost-economics framework, they argued that "different quality enforcement devices should be aligned with different governance of the supply chains." For many transactions, they were able to evaluate dominant governance structures. The food industry is closer to a hierarchy-like mode of governance in cases where reputation is the main quality factor; whereas market-like governance is more relevant in cases of public certification.

Smith [30**] described a computer approach (ReTrace) to address the reception and quality control data for tracking pallets from field/grower to supplier, importer, packing house to the customer. Bar coding (BC) was combined with email and a radio terminal (hand-held). A new product and a new company were created "Safetrack.co.uk". The integrated database successfully collected data for every link in the chain.

Da Silva *et al.* [31**] presented a solution for exchanging large quantities of data between retailers and suppliers in order to guarantee safety and quality of fruits and vegetables on the Portuguese market. They proposed a new information system architecture, integrated with enterprise resource planning that supported internet-based administrative functions. The case study used departments dealing with fruits and vegetables in one large retailer and some of its suppliers. The business process was designed and the solutions proposed were easy to apply and scaleable.

Bollen [32**] discussed the opportunities for quality variability/management and enhanced traceability of fresh produce in New Zealand. He also introduced the term Typical Traceable Resource Unit (TRU). The main drivers for traceability were regulatory requirements. Monitoring, prediction and management of quality variation were also important. Feedback information also proved to be crucial. Range of heat exposure, and maps of orchards with harvest location and dry matter distribution were depicted.

Risk analysis tools for quality management and traceability systems

Faucher [33**] explained that in industrial domains, systems are complex, and are also dangerous if out of control. He proposed a structured approach to identify potential failures that affect equipment, machines and processes. He showed that clearly identifying the situation is mandatory for analysing the consequences of failures and evaluating the seriousness level of criticality or acceptability, and finally, how and where to act. This method is normalised under NF X60-510 (France) and well suited for system analyses such as operational traceability.

Ishikawa [34**] presented several techniques for the Qualitician to rapidly put in place quality processes and improvements. He clearly presented data collections, their types, analysis, histograms for dispersion, cause-to-effect, Pareto diagram and many others. Other sources of information for Ishikawa and Pareto diagrams, as well as software tools for practitioners are also available [35–38]. Bertolini *et al.* [39**] presented an innovative way to look at procedures attached to production processes in farming and food industries, the Failure Modes, Effects and Criticality Analysis (FMECA). This is industrial engineering at its best to detect possible failures and proposed improvements. The authors presented the case of internal trace for wheat pasta in Italy.

Traceability tools

This section looks at automatic data capture, automatic identification systems, personal computers (PCs), personal digital assistance (PDA), and connection languages for uniformity and guidelines.

Doyon *et al*. [40**] described the importance and the availability of technologies other than BC and radiofrequency identification (RFID) for collecting data and performing identification without manipulation. These include two dimensional (optical character recognition) symbology, smart card, machine vision and biometry. The main logistic identifiers are global location number (GLN) and global trade item number (GTIN), as well as reduced space symbology (RSS), which recently showed potential.

Opara [41**] discussed advances in information technology for data capture, storage, retrieval, non-destructive testing and geo-spatial science, as well as genetic analyses, nanotechnology for miniature machines, and retinal images. Techniques used for tracking genes from seed to supermarket have also been reviewed [42**], and have focused on the tracking of plant genes as genetically-modified organisms (GMOs) during pre-commercialisation research, and post-commercialisation detection, identification and quantification. Science and policy challenged laboratory techniques and labelling was found to have an impact. The major critical areas are in the creation of standardised and validated methods and protocols. Data collection and protocols, filing through a laboratory information management system (LIMS) and using a vital element, the electronic laboratory notebook [43], were also found to be important for laboratories.

Heinrich and Betts [44**] had the vision to transform and adapt processes to create interactive business networks. Pervasive computer technology is also vital due to its incredible interactions with sensors, and the ability of the portable device to improve quality of life and support adaptive structures anywhere [45].

Giacomini *et al.* [46**] described the use of BC technology, scanner and LIMS for quality control of plant residues analysis during traceability, and included a cost analysis. Ritoux *et al.* [47**] presented some of the main identification and collection tools in agriculture and agri-food sectors in Canada including two dimensional coding and symbology, RFID, biometry and bimolecular DNA. Recent work precluded serious danger for unprotected RFID systems [48] when information and educational material are provided in websites [48]. Nobel [49**] reviewed the potential and limitations of RFID technology. Revenue for 2006 is expected to exceed US $3.2 billion and US $9 billion by 2009. Further success depends on finding popular applications beyond retail distribution.

Boucher-Ferguson [50**] reviewed RFID losses and discussed the various hurdles that remain to be resolved such as lack of international standards and return-on-investment (ROI) models, and the need to upgrade infrastructure to support RFID. The average price for tag is US $0.25–0.30 but should fall to US $0.09 a clip. The technology requires infrastructure with viable hard- and software and might need more servers and databases. It is suggested that a real-time, case scenario, study is critical in the business process.

Raspor [51**] reviewed the use of bio-marker technical solutions in different circumstances. Suitable markers need to be stable and traceable all along the food chain. Their functions could be technical with nutritional aspects. Currently, genetically-modified food is traced with DNA alteration but other techniques such mass spectrometry (MS) and induced-coupled plasma MS exist. Equally important are primed *in situ* labelling and fluorescence *in situ* hybridisation detection methods for the chromosome level to specific genes, and magnetic resonance, positron emission tomography and single photon emission computerised tomography. High output technologies, such as DNA microarray can be used to trace genes. The author noted that the number of permanent markers is limited and standardised protocols are still rare [51**] . Bio-markers are slowly emerging in food science and technology and becoming an important tool in decision making processes.

Bagnaresi *et al.* [52**] reported on interesting differential methods used to detect the proteins patatin and granule-bound starch synthetase 1. Sodium dodecyl sulphate polyacrylamide gel electrophoresis of potato tuber fraction, starch analysis and matrix assisted laser desorption/ionisation-time of flight MS were discussed. This preliminary research promises to differentiate organic versus conventional agricultural practice.

Terry *et al.* [53**] reviewed the application of biosensors to fresh produce and wider food industries. The principles of biosensor technology were also outlined in detail; biosensors convert a biologically-induced recognition event (ie, enzyme, antibody) into a detectable signal via a transducer and processor. The result is a display depicting both the presence and the concentration of the product. Electrochemical, calorimetric, optical, acoustic, immunosensor, sensor arrays and whole immobilised cells (usually bacteria) are discussed as recognition elements. The field is open for improvement of quality control methods for fresh produce.

Gadani *et al.* [54**] described the detection of GMOs as an identity allowing segregation and traceability within and throughout the supply chain. Polymerase chain reaction-based methods for qualitative and quantitative determination and identification of GMOs are also described.

Kelly [55**] introduced isotope ratio-mass spectrometry (IRMS) to detect economic fraud and adulteration in food production, and improve traceability. Trace element and radio-isotope ratio analysis offer the most promising hypotheses for establishing geographic origin. It is also very important quantify repeatability and reproducibility of measurements, and there is a need to build a database of information for enforcement purposes. Finally, it is critical to understand how meteorological and geochemical signatures are transferred into food systems. Kelly *et al.* [56**] studied and applied multi-element and multi-isotope analysis to tracing geographical origin of food. The basis is the European Union Protected Food Names and Schemes. Determination of geographical origin was reviewed. Cases reviewed include meat, dairy, dairy products, beverages, cereal crops, wine, and extra virgin olive oil and its extract.

Wang *et al.* [57**] provided an overview of the recent development of wireless sensor technologies for communication, and discussed advantages and obstacles that prevent their fast adoption. The authors also presented future trends for this sector, in particular, with the high demand for assurance of food quality, health benefits and safety. Kamoeka *et al.* [58**] investigated the setting up of sensing devices in combination with information systems (databases) to monitor quality at farm levels in Japan. The standard language was XML. The plants under study were tomato, spinach and lettuce, with non-destructive testing using laser-induced fluorescence and soil moisture by near infrared. The database system was with Java Applet Typed analytical tools for colour, shape and spectroscopy. The bio-information exchange system seemed to have the potential for traceability of produce, field and quality.

Golan *et al.* [59**] investigated traceability in the USA and found that private sector firms have a substantial capacity to trace. Studies were based on fresh produce, grain and oilseeds, as well as cattle and beef, using selected milestones in the USA's traceability requirements for foods. Results showed that the private sector has developed a number of mechanisms to correct problems. The private sector uses contracting out, third-party safety/quality audits and industry-maintained standards. Benefits and costs are delimited and vary across industries.

Carantino [60**] presented RFID as a promising tool that is still limited by its price. Its application areas are industrial, logistics and distribution. It allows reading and writing from very close to long distances. RFID has allowed knowledge of the exact location of products in a warehouse. The pioneers were Wal-Mart, Tesco, Metro and Carrefour in France. Future store and Metro trials showed that efficiency improved by 12–17%, stolen goods were reduced by 11–18% and product availability improved by 9–14%. However, tag prices are still an important limiting factor, and dead zones in reading capability in shelves are also of concern.

Global Standard 1 (GS1) standards have been accepted to harmonise the logistics of traceability and inter-operability of electronic data transmission [61**]. As a result, pallets are identified with EAN-128 and notice of expedition with EDI. The coding of logistical units is done with serial shipping container code (SSCC). All product codes (trade unit) are with GTIN.

The e.centre, the UK authority for the European Article Number-Uniform Code Council (EAN-UCC) system is recognised as the champion of open standards with the main structures being BC and computer to computer messaging. The fresh produce supply chain has changed and has completed the stabilisation process [62**]. In Europe in 2001, large supermarkets were the biggest customers of fresh produce with 79% of the whole market. Among six types of identifiers, the three most relevant were GTIN, GLN and SSCC. Business electronic language is still EDI and XML. One remaining major concern is the individual coding of fresh produce. Currently, retailers use the PLU system. In North America, one potential solution is a small BC or RSS. From a cost benefit analysis (CBA) in 100 supermarkets in the USA, the savings from improved inventory control could reach US $2.3 million. Scanning, scale and software equipment under 2 years old can be upgraded for about US $2,500 per store.

Schwägele [63**] and Smith *et al.* [64**] presented articles from European and USA traceability perspectives, respectively, on feedstuffs, and animal and processed meats for human consumption. Countries were compared with respect to compliance with identification and trace systems locally, nationally and internationally. Governmental agencies were involved to minimise product recalls and make crisis protocols more effective in any events. Overall, traceability is becoming an integral feature of markets for all foods. The application of bio-sensors (immunoelectrodes and optical fibre bio-sensors) is even more widespread. Computer modelling and risk assessment are being used to predict risks for greater control in order to protect human health.

Kleist *et al.* [65**] discussed the basis of RFID labelling, data transport layer (electronic product code and smart labels), industry initiatives, deployment model and case analysis (proof of concept). Finkenzeller [66**] described the fundamentals and applications of RFID. Physical and operating principles of systems were detailed. Palmer [67**] and Ash *et al.* [68**] were two technical commercial application driven documents for teaching, educating scientific and non-technical individuals about BC reading, printing, specification and application.

Traceability terms, definitions, concepts, working principles, international standards and guidelines

Schaeffer and Caugant [69**] created a practical guide to the definitions, applications and limits of traceability in the production and processing sectors. A step-by-step methodology to build a total system for the enterprises is presented. Examples are given for potatoes, apricots, peaches and nectarines.

Agence Française de Normalisation (AFNOR) [70**] guides the user through agri-food-sector specific clusters to GMP for the vegetable quality-model. It covers identification and traceability for fresh potato production and reception/delivery acceptance. GMP, BC operation, specifications/symbology, RFID principles and operation are well discussed. Viriuéga [71**] presented an overview of the evolution of the concept of traceability from the 1960s to 2005. The standards and methods for traceability are discussed, with traceability being identified as a new sector by itself.

The Whitepaper from Datamax Corporation (Orlando, FL, USA) on full traceability for the European Fruit and Vegetable Supply Chain [72**] was based on the well-structured European Article Numbering (EAN) family for products labelled to all points; grower/packer, shipper/logistics and retailer levels. Food safety was defined as global concerns. The main thrust was toward GMO contamination, foodborne illness and bio-terrorism threats. The little information available was specified for retail, shippers/logistic and farmer/producer point.

Tavernier [73**] presented an analysis of producers' perceptions of traceability in organic agriculture. He reviewed standards or guidelines and likelihood of Federal government intervention to improve traceability for consumers in the USA. This study was conducted in New Jersey with 631 farmers. Six demographic valuable populations were considered. Results showed that organic producers with sales under US $50,000 indicated their willingness for government to increase efforts to improve traceability from consumer back to producers. However, producers with sales above US $50,000 thought the opposite. People with higher education (Bachelor's Degree) had a negative perception of tracing. No clear cut consensus for accepting guideline/standards was apparent.

Schiefer [74**] reviewed traceability and certification on QA systems, and major initiatives on policy agricultural groups and industries. Infrastructure was based on a large number of small production enterprises (farmers). Certification on QA was considered a good tool for ensuring trust certification.

The EAN International Fresh Produce Traceability Guidelines 2001 [75**] was aimed at proposing a common approach to tracking and tracing produce by means of EAN-UCC internationally accepted numbering and BC. The minimum requirements, and the products, origin and locations are accurately and timely identified resulting in efficient recall potential. It recommended using common identification and communication standards. Pilot projects were completed in Belgium, Namibia, New Zealand, South Africa and Spain. There was also a banana supply chain traceability guideline.

The Canadian Produce Marketing Association (CPMA)/Produce Marketing Association (PMA) guide [76**] is a document for implementation between the PMA (USA) and the CPMA (Canada). This document included an executive summary, data, and elements for traceability with two functions: mandatory and optional data. Mandatory encompassed master data that seldom changes and transactional data. This was in accordance with Can-Trace data standards. Data elements across the supply chain includes primary producers, processors, wholesalers, distributors/retailers, and data to collect, keep and share. Implementation approaches are paper-based and human-readable; automatic-technology-based (BC) and RFID-based. The 10 best practices were also summarised.

Can-Trace [77**], an industry-led initiative that offers global traceability information and links, is a collaborative and open initiative committed to the development of traceability standard for food products in Canada. A second version of the Canadian Food Traceability Data Standard should be available by the first half of 2006. GS1 Canada is the Secretariat's initiative. The mission defines and develops minimal requirements based on the EAN-UCC system. Gencod-EAN [78**] is used as a common reference document for implementing traceable systems between partners in a supply chain. This French guide is composed of definitions from ISO-8402 with many explicit flow diagrams. It also includes structural traceability factors, essential issues, principles and options, description of a traceability system, implementation, case studies and a glossary.

EAN International [79**] is a traceability management tool for agriculture, food and beverage products as well as GS1 2006. The global traceability standard supports visibility, quality and safety in the supply chain. The new documentation from GS1 provides global standards for BC, RFID-based identification and electronic business messaging, the environment for global data synchronisation and CPMA/PMA. This guide is applicable across the supply chain. The technical traceability standard is available and summarised in a four-page format. This new standard can be integrated with previous operational and detailed guidelines and include new tools to view and navigate with the GS1 XML 2-02 language.

Furness and Smith [80**] described the urgent need to harmonise the wide range of methods available for identification and management of food entities, since individual stakeholders are using their own methods. It is critical to develop a generic framework which is explained in detail. The standardised approach is the EAN-UCC standards and guidelines.

Doyon *et al*. [81**] reviews terminology and definitions generally recognised in North America and with ISO-8402. These authors showed the existence of important discrepancies between numerous definitions and their understanding. Reliability, perception of value from the client and probability of failure in the future was linked to spread of recall. Components of internal flow in processing and minimum components of trace systems are schematised in comprehensive graphics. The main initiatives on safety and traceability in Canada were presented. Moe [82**] explained the fundamental features of traceability and the terms of ISO-8402. He added up four distinct contexts with different implied sense: product, data, calibration, information technology and programming. He included a step, a chain, a product, and case entities with its essential descriptions and sub-descriptions. The Food Traceability Report [83**] included keywords on traceability, very informative news and events, and generated 155 hit documents; but requires fees for access.

Vergote and Lecompte [84**] described a method for estimating the tools for food traceability, examining the applied systems, size adaptation and needs for each industry. Definitions and technical concepts were also structured on ISO-8402. Still ascending and descending, internal traceability has to be mastered and implemented. The complexity of linkage between lot of raw material, in-progress and finished product has to be understood. How to correctly associate and trace information flux with product physical flux is also critical. An extract from AFNOR NF V46-010 is detailed. The objectives of traceability for enterprises and the diagnostic process were equally discussed. A practical case was demonstrated with a milling enterprise.

Viruéga [85**] described 10 reasons and five recommendations following the new EC Regulation 178/2002, Article 18 that became effective on January 2005. The four main ideas presented included the new EU obligations to proof traceability, which is also internally the best tool for recall purposes, an argument tool facing regulatory framework, the extended needs such as for sales and marketing impact, as well as relevance for supplier selection. From the interior, an enterprise can improve its information technology system for quality improvement and internal processes analysis. Equally important is better management of material-added information flux. In conclusion, tools and methods are needed to choose the best traceability solution for each situation. Multi-service enterprises are required, as well as coordination of internal and external trace data. Choosing inter-operable standards is seen as a value added, positive effort.

Salat [86**] described the adaptation of the fruit and vegetable sector to the new EC Regulation 178/2002 that fixes procedures for food safety in the food chain. It specifies that from October 2006, material or objects in contact with food must also be traceable. The case of melon was detailed. The EAN-128 code label is fixed to pallets. Training is essential for successful traceability of ascending and descending processes. Practical data-protocol files were elaborated on and the ornamental horticulture sector was also presented as an active player.

Conclusions

“Traceability is becoming an Index of Quality and also, an inter-disciplinary concept” [41**]. Information structures proposed by EAN-UCC guidelines and Can-Trace with CPMA/PMA initiative on produce and on-farm safety are showing the path. Fresh produce of interest were potato, lettuce, spinach, soy, kiwifruit, pipfruit, pineapple, tomato, cabbage, melon and banana.

Of the family of traceability principles, definitions and related terminology, the most interesting areas where there is consensus are ascending, descending, total and integrated traceability. It is clear that there are links between ISO-8402 (95), ISO-9001:2000, ISO-2200 (HACCP) and traceability guidelines and standards. Guidelines for Fresh Produce Traceability are available from EAN-UCC 2001 and from the CPMA/PMA Guide to Implementation 2005.

Risk and safety analysis tools and solutions applicable to the QA system and traceability system malfunction are introduced by diagrams such as Ishikawa and Pareto, as well as FMECA system analysis. Besides manual keying and written instruction, automatic identification and data capture (AIDC) technologies are also presented with some practical cases.

Very little data or information are available on advantages and costs, related to traceable technology, training and possible choices (ie, CBA and ROI).

More globally "Traceability in the Supply Chain: From Strategy to Practice" 2000 from Gencod-EAN, France is available. Finally, an updated version (2006) of the GS1 Global Traceability standard is also accessible through the web.

Future research

There is a definite lack of technical know-how, basic knowledge and technology applications in the food industry where logistic systems, operational research, advanced computer software and intelligent sensors are concerned. There is, in many cases, ignorance of proven engineering of industrial principles such as cause-to-effect and Pareto diagrams construction and utilisation, as well as the failure mode principles effect applicable to quality and traceability systems. Sound adaptive business network between partners must be put in place in successful total integrated chain technology and with cost efficiency. Computer engineering and ubiquitous sensors are becoming irreplaceable partners and research as well as validation protocols are required. The same applies for artificial vision and RFID technology. Problems include a the lack of encryption practice and non-efficient protection against viruses and fraudulent practices.

In the future, one should see:

- the creation of regional solution and computer power (hubs and grids) to support regulatory, policy and food quality, safety as well as trade.
- requests by consumers, industrial clients, associations and inspection agencies from the web and using specific BC, RFID unit identifiers or images to instantly verify lot quality and quantity, specification, site of production and lab results. All of these must be instantaneous, anywhere, at anytime, and of course under protected environment.
- international uniform training for Qualitician; technologist, engineer, economists, agronomists, veterinarian and alike, to obtain accreditation as a traceability and food system professional.
- an active operational regional branch of and an International Association of Traceability experts and food networks, as well as computing devices and sensors, including annual meetings and a refereed journal.

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References

Papers of interest have been highlighted as:
** Essential reading

1 Gould WA and Gould RW. Total quality assurance for the food industries. 3rd Ed. CTI Publications, Inc: MD, USA; 2001: pp 452 .

**This book sets the basic principles of total QA for management and employees in the food domain. In the second part, various attributes and characteristics of food and quality evaluation are described and the ``Fishbone Chart`` or the cause-to-effect product quality diagram is introduced. In this case, this is the CEDAC or the cause and effect diagram with the aid of cards. There are also links to statistical control charts.

2 Durival M, Voirin T and Lacour F. Réussir votre usine alimentaire: de la décision d'investir à la rédaction du cahier des charges. Lavoisier. TEC/DOC. Ed. RIA. Paris. France; 1994: pp 248.

**The authors want to create a profound reflection from enterprise's management and owner about investing in new construction, engineering and quality installation for food plants. This guide is divided in three parts; the methods, technical studies and construction with sub-projects, and detailed consultations. With quality lab structure and manufacturing, understanding material and information flux are a must to master under HACCP principles.

3 Daguisé, F. Profession: Qualiticien. Tous les métiers de la qualité et leur évolution. Dunod, Paris, France. 2000: pp 202.

**The writer puts the importance on five segments for the reader or quality professional to master in quality system fundamentals. 1. history and up to today's evolution; 2. the art of the profession Qualitician; 3. the complementary function of a Qualitician; 4. the qualification and diploma level including future field of work; 5. next step for standards and future vision.

4 Rose DJ. TQM systems. In: auditing the food industry: from safety and quality to environmental and other audits. Dillon M and Griffith C (Ed). CRC Press: Woodhead Publishing Ltd: Cambridge, England; 2001: pp 70–91.

**The author introduces the scope of quality system, the development, the implementation, performance measuring and audit, and benefits and future trends.

5 Knight C, Stanley R and Jones L. Agriculture in the food supply Chain: an overview – key topics in food science and technology No. 5. Campden & Chorleywood Food Research Association Group (C&C) RASE. Gloucestershire, UK; 2002: pp 127.

**The authors describe the many interactions between various organisations whose technical support encompasses different sectors of the food chain in the UK. This document aims to help food companies better understand each other. It covers production, holding practices, food safety issues, food quality and regulations. Integrated food supply chain, HACCP and traceability, and applications for lettuce, potato and wheat are discussed.

6 Lahellec C. Risques alimentaires. TEC/DOC Lavoisier: Paris, France.; 2005: pp 476.

**This book is divided in five main themes: First, food wholesomeness and security is composed of three chapters such as food risks, today's scientific status and how domains such as social science and humane science research are able to analyse them. The second chapter presents the evolution of evaluation structure of food safety and methods of prevention. The third chapter describes a new approach to risks, simulation to service risks control and crisis prevention, and other sanitary risks and environments. The fourth chapter presents the causes and crisis management, the due diligence principle. The final chapter shows the better knowledge to better prevention, beyond hygiene and HACCP, rules and regulation systems, the learning curve difficulties, ethical problems, possibility of classification the risks by their importance, view from the insurer, risks and the law. Finally, the conclusion on risks management, and the active communication to continue vigilance in food quality and safety issues are presented.

7 Gehlkopf M. The BRC (British Retailer Consortium) Global Food Standard. In: Option-Qualité 2005: 237: 16–22.

**The author presents the reflections of the Grand Distribution stakeholders, their role and responsibility in relation to food security (safety). Thirteen societies are participating in a six-certification body. He discussed in length the BRC referential and traceability system, and provides detailed information from their websites http://www.brc.org.uk/defaultnew.aspe and http://www.brc.org.uk/standards/about_food.htm for the Global Standard Food Version 4.

8 Sahasrabudhe J. Food Safety Systems : Using preventive not reactive means to assure safety. Canadian Food safety Management: 2006 :2(1): 6–7.

**The author describes the complexity of acronyms in food safety for non users. Various stakeholders are described in the Canadian food supply chain. Documentation for food safety systems is a must to ensure safety verification.

9 Chambers A. Canadian producers lead the world in HACCP-based programs. Canadian Food safety Management: 2006:2(1):15.

**The author briefly introduces the Canadian producer-led national and accessible commodity-specific HACCP-based program, Canadian on-Farm Food Safety. In total, 29 commodity-specific initiatives are in action. Tools exist to respond to demand from market locally and internationally. www.onfarmfoodsafety.ca

10 USFDA/CFSAN. Guidance for industry: guide to minimize food safety hazards of fresh-cut fruits and vegetables. (1st Draft). College Park, MD, USA; 2006 : pp 1–41.

**The FDA presents a new guide on how to minimise microbial safety hazards in fresh-cut preparations. This is a twelve-section paper, covering documentation, record keeping and trace back, recall, and identification for full chain implementation. Also attached are multiple web sites on food product safety. http://www.cfsan.fda.gov/guidance.html

11 USDA/FDA. Foodborne Illness Education Information Center. www.nal.usda.gov/foodborne

**Produce safety links are provided from the main organisations. www.fsic@nal.usda.gov. www.foodsafety.org. It contains product information and educational materials, including HACCP as well as government web sites (33) and non-governmental websites (33).

12 Gombas DE and Stevenson KE. HACCP verification and validation. An advanced HACCP workshop. 2nd Ed. Food Processors Institute (FPI). Washington, DC, USA; 2000: pp 268.

**A practical view on HACCP, its verification, pre requisites, critical control points, verification, auditing, regulations, etc. for the USA from the Food Processor Association point of view.

13 Leat P, Marr P and Ritchie C. Quality assurance and traceability- the Scottish Agri-food Industry's quest for competitive advantage. Supply Chain Management: An International Journal 1998:3:115–117.

**The authors studied how the Scottish agri-food industry has been developing farm and quality assurance activities as early as the 1990s. It outlines the European system of third-party certification. The paper was an introduction to a conference in food traceability, held in Edinburgh, linking competitiveness to food chain and quality assurance.

14 Wilson TP and Clarke WR. Food safety and traceability in the agricultural supply chain: using the internet to deliver traceability. Supply Chain Management: An International Journal 1998:3:127–133.

**This paper describes possible mechanisms for design and development of software systems that could become an industry standard for collection, location, dissemination of traceable data. The system proposed makes use of the growth of personal computers, declining cost of telecommunication and the globalisation of internet.

15 Jonker TH, Hiroshi I and Fujishima H. Food safety and quality standards in Japan–compliance of suppliers from developing countries. In: The World Bank. Agricultural and Rural Development (ARD) Ed. The International Bank of Reconstruction and Development/The World Bank. Washington, DC. USA; 2004: pp. 1–50.

**This report on the compliance of suppliers from developing countries to Japan includes shrimps, Nile Perch, fruit and vegetables (mango, pineapple, green soy beans and green asparagus) with criteria for complying with standards. Interactions and costs, if controlled for buyers, is presented. Suggestions for improving compliance of suppliers are provided. Buyers' priority standards and supplier compliance are discussed and joint training is recommended by the Japanese for capacity building and composed of eight critical elements. http://www.worldbank.org

16 Soler A and Marie-Alphonsine PA. Establishing a quality certification process within the martinican pineapple industry. Acta Horticulturae 2005 IV International Pineapple Symposium 666:337–339.

**This article discusses the re-engineering of the pineapple production system in the Martinican industry to meet consumer demands. Food security, environmental protection, product quality and traceability are societal priority requirements. The goal is to maintain and improve confidence for the international markets. The "Agriconfiance" production certification and ISO guarantees product traceability and security. This is a joint project between Pôle de recherche agronomique de Martinique (Martinique) and the Centre de Coopération Internationale en Recherche Agronomique pour le Développement - Département des productions fruitières et horticoles (France) for this re-structuring action.

17 de Sousa A and Waters E. Are you assured? (Fresh produce quality assurance.) Fresh Produce Journal 2004: 3: 21–22, 24.

A short review of quality assurance programs in Europe, Africa, Chile and the UK and their impact across the sector.

18 Guidelines for implementing EUREPGAP Protocol for fresh fruit and vegetable producers; 2001. http://www.agribusinessonline.com/regulations/eurepprotocol.pdf and http://www.eurepgap.org/languages/english/news/245.html

**The paper sets out the framework for GAP on farms. The 15-part document includes traceability to auditing.

19 Snoekx P, De Baerdemaeker J, Hertog M and Nicolaï B. Model for prediction of horticultural product quality evolution along different supply chain scenario paths. Acta Horticulturae 2005:674:359–366.

**The article describes emerging electronic traceability tools in combination with produce for prediction of quality evolution. Called specific quality tracing system, the aim is to describe the actual design of a model for horticultural produce in the food supply chain. It is under development.

20 Tapia MS and Welti-Chanes J. Approaches for safety assessment of minimally processed fruits and vegetables. In book: Engineering and Food for the 21st century. Ed. (Welti-Chanes J, Barbosa-Canovas GV and Anguilar JM). CRC Press: Boca Raton, Florida, USA; 2002: pp 671–694.

**This paper introduces various approaches for safety (GMP and HACCP) of minimally processed fruits and vegetables from the industry side or the regulatory perspectives. A table defining risk assessment, predictive microbiology, with examples is presented. The great interest is consumer oriented.

21 Nicolaï BM, Bobelyn E, Hertog M, Marquenie D, Verboven P and Verlinden B. Quality manipulation and monitoring in processes: product-climate interaction, quality control. Acta Horticulturae 2003:604: 265–275.

**The authors show that quality of fruit and vegetables changes drastically following harvest. An overview is presented of some developments in technologies and quality monitoring.

22 de Wit W. Dutch food authority: objectives and organisation. Acta Horticulturae 2003:611:33–35.

**The author provides in depth information on the evolution of the new Dutch Food Authority to restore consumer confidence in the safety of their food. Post crisis food evolution has underlined the complexity and the lack of transparency in legislation, in monitoring, in investigation and in enforcement procedures. The Netherlands has created the new Dutch Food Authority, to analyse and put in perspective, a chain-oriented approach to ensure food safety. This agency will coordinate and direct food policy, research, monitoring and inspection, and advise the public on methods of food safety.

23 Dillon M and Dillon M. Food standards and auditing. In: Auditing the food industry: from safety and quality to environmental and other audits. Ed. Dillon M and Griffith C. CRC Press, Woodhead Publishing Ltd: Cambridge, England; 2001:pp 5–16.

**The article emphasises why standards have become so important, what they are and the principled outlining the standard setting process. Terminology explanation on standards and specifications with qualitatives such as transparency and voluntary, and some regulatory international bodies and agency-committees are presented. The need for auditing and its importance is described as a worthwhile challenge.

24 McEachern V, Bungay A, Ippolito SB and Lee-Spiegelberg S. Regulatory verification of safety and quality control systems in the food industry. In: Auditing the food industry: from safety and quality to environmental and other audits, Dillon M and Griffith C (Ed). CRC Press, Woodhead Publishing Ltd: Cambridge, England; 2001: pp. 29–47.

**The chapter discusses the role of safety and quality control systems, the principles of effective food safety and the role of government and industry, the regulatory verification versus audit and the food industry, the Canadian approach to food inspection as well as the future integrated approach.

25 Praat J-P, Bollen F, Gillgren D, Taylor J, Mowat A and Amos N. Using supply chain information: mapping pipfruit and kiwifruit quality. Acta Horticulturae 2003: 604:377–385.

**The article demonstrates that technologies can bring in added value to information and, its ability to transfer seamlessly from producers, postharvest points and marketing components of the supply chains. A key difference is the ability to transfer information effectively. Paper is replaced by geographical information, handheld capture devices, remote sensing and data base management means. The work is better optimised on the physical and financial aspects of horticultural production systems. In addition, we are in the making an auditable product traceability achievement. Cases are presented for mapping pipfruit and kiwi to identify current limitations of various technologies.

26 Habib R, Nesme T, Plénet D and Lescourret F. Data modelling for database design in apple production monitoring systems for a producer organization. Acta Horticulturae 2001: 566:477–-482.

**The authors present the general rules of data modelling based on semantic structure of information and their application to the construction of a basic data model. The model provides for a sound basis for database scheme to prevent redundancy and support application to apple production monitoring at the level of the producer organisation. It allows one to trace fruits from individual plots up to commercial lots.

27 Jansen-Vuller MH, van Dorp CA and Beulens AJM. Managing traceability information in manufacture. International Journal of Information Management 2003:23:395–413.

**The authors propose an approach to design information systems for traceability. They apply the Gazinto graph method to trace goods flow. The graphical listing is transformed into a reference data. By registering all relations between sub-ordinate and super-ordinate material lots, a method of tracking the composition of the end products is generated. The bill of lot then provides the necessary information to determine composition of a material item out of component items. The composition data can be used to recall, to certify product quality or to adjust production processes or optimise.

28 van Dorp CA. Reference-data modelling for tracking and tracing. *PhD Thesis.* Wageningen University and Research Centre (WUR). The Netherlands; 2004.

**The work undertaken represents and describes research fundamentals of reference-data models in tracking and tracing. Better information systems are tailor made for traceability purposes. It is composed of five informative core chapters, with relevant data models, adequate reference data evaluation of the application and new areas for research.

29 Raynaud E, Sauvée L and Valceschini E. Alignment between quality enforcement devices and governance structures in the agro-food vertical chains. Journal of Management and Governance 2005:9:47–77.

**This paper describes the supply chain governance aligned with the quality enforcement mechanisms used in transactions with customers to ensure quality. The main discussion is about where private brands assure quality to chains and, officials certifications assure products quality to customers. Work is conducted on a set of 42 cases and three agri-food sectors (meat, cheese, fruits and vegetables) including seven European counties.

30 Smith J. Traceability systems take closer control from seed to shelf. Fresh Produce Journal 2001:19:13–14.

**The author detailed BC and handheld application to trace produce from farm to clients locally, as well as international linkage through the integrated data base Safetrack, sharing pertinent information.

31 da Silva MM, da Silva LM and Salema JP. Using information systems to increase food quality and safety in the Portuguese market for fruits and vegetables. In: Dynamics in chains and networks: Proceedings of the 6th International Conference on Chain and Network Management in Agribusiness and the Food Industry, 27–28 May 2004 :184–191.

**The authors demonstrate a Portuguese application of exchanging large quantity of data about field crops: quantities, dates of fertilisation and pesticides applications from paper-based to information technology. Case solution of one retailer and two suppliers are presented. Discussion of the various technologies is presented. The future is promising for such an application.

32 Bollen AF. Traceability in fresh produce supply chains. Acta horticulturae 2005:687:279–288.

**The writer mentioned the great interest in improving supply chain performance. Cases are presented that provide feedback to growers and market. It is important to manage quality variability, information flows, and uncontrolled mixing of produce.

33 Faucher J. Pratique de l'AMDEC. Assurez la qualité et la sécurité de fonctionnement de vos produits, équipements et procédés. Ed. Dunod. Paris, France; 2004: pp. 1–177.

**The book describes the approach to prevent and forecast risks situations in product, process and control manufacturing or system operations. Effects and causes criticality are discussed with examples. Structure and construction tables, failure systems, how-to and risk evaluations close the review.

34 Ishikawa K. La gestion de la qualité. Outils et applications pratiques. Ed. Dunod. Paris, France; 2002: pp 1–242.

**The author is keen on practical know-how learning and test case situations. The main chapters encompass data collection, data description (histograms), cause-to-effects diagrams, data collection sheets for defects and localisation, Pareto and various figure generation, correlation or dispersion, binomial probability, sampling and inspection.

35 Fishbone diagram or cause-to-effect diagram from K. Ishikawa. (Japan). An analysis tool that provides a systematic way to map potential or root causes of various sorts of problems. Some software exist to simplify the logical construction.

http://www.smartdraw.com/specials/decisionfishbone.asp?type=12204&id=12204

http://quality.enr.state.nc.us/tools/fishbone.htm

http://www.skymark.com/resources/tools/cause.asp

http://www.saferpak.com/cause_effect.htm

36 Pareto diagram: a special form of bar graph used to display relative importance of problems or conditions. Ranking and frequency are easy to visualise and facilitate problem analysis. Software exist also to ease the decision process.

http://www.sytsma.com/tqmtools/pareto.html

http://www.isixsigma.com/library/content/c010527a.asp

http://www.winstat.com/english/function/graphics/pareto.htm

37 FMECA and FMEA. Failure Mode Effects and Criticality Analysis. Definition and software applications. Overview, standards, guidelines, procedures, risk evaluation, risk priority number, critical analysis, etc.

http://www.itemsoft.com/ and http://www.weibull.com/basics/fmea.htm

38 AMDEC. Analyse des modes de défaillance effets et criticité. Methods and some software available, French version.

http://chaqual.free.fr/outils/amdec/amdec.html

http://perso.wanadoo.fr/olivier.albenge/page_site/qualite/methode/amdec.htm

http://www.tdc.fr/fr/produits/tdc_fmea.php

http://www.univ-angers.fr/docs/etudquassi/AMDEC.pdf

39 Bertolini M, Bevilacqua M and Massini R. FMECA approach to product traceability in the food industry. Food Control 2006:17(2):137–145.

**Application of industrial engineering tool, the Failure Mode Effect and Criticality Analysis, to production process in the farming and food industries. Aimed at detecting the possible critical points in traceability system.

40 Doyon G, Veilleux P and Clément A. Food quality and global traceability for e-commerce through automatic data capture process:new bar codes and RFID technologies. In: Seafood quality and safety. Ad-

vances in the New Millennium. Shahidi F and Simpson BK (Ed). ScienceTech Publishing Co., St. John's NFLD. Canada; 2004:39–59.

**The authors describe the importance of AIDC for quality assurance, good manufacturing practice and traceability systems. The importance of ECCC-net now GS1 Canada products and services is introduced to the public. Reduced space symbology is presented for produce, pharmaceutical and laboratory vials applications. A brief description of various radiofrequency utilisations with strength and weaknesses with respect to food industrial environment close the paper.

41 Opara LU. Traceability in agriculture and food supply chain: a review of basic concepts, technological implications, and future prospects. Journal of Food, Agriculture and Environment 2003:1: 101–106.

**The author describes a review of basic concepts, technological applications and future prospect of traceability in agribusiness. He introduces six elements of traceability. Also, cost-effective technologies is an important challenge in a global economy. Quality and safety measurements being destructive or non-invasive as well as on line and data managements need research, improvement and connectivity. Consistency of quality locally or overseas presents for traceability partners motivation, challenges and opportunities. Traceability could become an index of quality. Advance in computer and information technology are needed and, adaptation for small-scale farmers and for developing countries, are a must at local level and abroad.

42 Auer CA. Tracking genes from seed to supermarket: techniques and trends. Trends in Plant Science 2003: 8(12): 591–597.

**The author reviews the tracking of plant genes from seed to supermarket looking at the laboratory techniques at pre- and post-commercialisation process for detection of gene flow, identification and quantification of genetically modified crops. A glossary of terms speeds up comprehension as well as comparison of laboratory techniques with analyses and the type of measurements. Science and policy challenge laboratory techniques as well as food labelling and traceable proof. Social, biological, and agricultural aspects are associated with biotechnology.

43 LIM and ELN. Laboratory information management and electronic laboratory notebook. Helpful to implement continuous traceable data.

http://www.atriumresearch.com/

44 Heinrich C and Betts B. Adapt or die – transforming your supply chain into an adaptive business network. John Wiley and Sons, Inc. New Jersey, USA; 2003: pp 234.

**These authors discuss how existing supply chain models are not responsive enough to today's changing business environment. For them, the combination of roles and responsibility within a network and how to prepare for an adaptive, effective business networking era, are most important elements for success and survival.

45 Pervasive computer technology/ubiquitous technology. Definitions, applications and future in any supply chain. The incredible interactions of sensors, computers and portable devices to improve life quality and business.

http://www.computer.org/portal/site/pervasive//

http://en.wikipedia.org/wiki/Ubiquitous_computing

http://searchnetworking.techtarget.com/sDefinition/0,,sid7_gci759337,00.html

http://news.com.com/Supply+chain+reaction/2009-1008_3-996043.html

46 Giacomini C, Mancini MC and Mora C. Case study on the traceability systems in the fruit and vegetable sector. In: Meeting the challenges of sustainable livelihoods and food security in diverse rural communities 2002 IFSA. November 17-20. Lake Buena Vista (USA): 1-10 pp http://conference.ifas.ufl.edu/ifsa/papers/e/a17.doc

**It represents the first replies from the Italian agricultural system to growing demand for traceability. The implementation is done with co-operatives that regroup 500 small and medium size fruit farms. For them, this is an important marketing incentive. They discuss the information system, the costs, the case study, the models, and the use of LIMS for quality control. BC is the main technology. Three types of benefits are discussed.

47 Ritoux N, Doyon G, Veilleux P, Clément A and Lagimonière M. Des outils pour suivre à la trace. Procédés et technologies. L'Actualité Alimentaire 2004:1:40–41.

**This trade magazine document outlines the various technologies from linear, two dimensional coding and symbology, RFID, biometry and bio-molecular DNA. It also discusses strengths and weaknesses of BC and radiofrequency waves.

48 Rieback MR. RFID virus and worms. Department of Computer Science. Vrije Universiteit Amsterdam. http://.rfidvirus.org/index.html, http://cnd.iit.cnr.it/percom2006/program.html

www.rfidguardian.org and www.rfid-101.com

49 Nobel C. Symbol considers RFID options. eWeek 2006:23 (7):35.

**The article describes potential and limitations in RFID technology. Some of the objections were that the RFID is not growing or becoming in place until the technology proves itself in new applications. People have to understand the real potential of it. Meanwhile the revenue will exceed US $3.2 billion in 2006; the overall RFID revenue for 2009 is expected close to US $9.0 billion. Success will depend on finding popular applications beyond retail distribution.

50 Boucher-Ferguson R. RFID losses reception. High tag costs are still putting the kibosh on returns on investment. eWeek:2006:23(10):11.

**The writer describes many hurdles that remain to be resolved such as the lack of standard and ROI models to better perception of RFID tags. The pricing is around US $0.25–0.30 but, some predict the price will go to US $0.09. The technology requires infrastructure with viable hard- and software and might need more servers and databases. It is suggested that a real-time, case scenario, study is critical in the business process.

51 Raspor P. Bio-markers: traceability in food safety issues. Review In: Acta Biochimica Polonica 2005:52:659–664.

**The writer targets the development of biological identification technologies and DNA tests enabling individual farm animal testing. It can help to preserve the identity of unique quality traits and promote innovation in the food sector. Using biological markers can be defined as anatomic, physiologic, biochemical or molecular parameters; all will concur to ensure traceability. The validity of biomarkers is the ultimate driving force for their applicability. They would be useful in reducing uncertainty in food and also biological assessment. It is good for GMO detection with DNA micro array. Improvements are needed with respect to design and optimisation of the applied protocols. Biomarkers are stepping into the food science and technology with high potential to add value for producers and consumers alike.

52 Bagnaresi P, Sabatini L, Ranalli P. Bio-molecular markers for traceability of organic vs. conventional potato tubers: a preliminary investigation. ISHS Acta Horticulturale 2005:684: 25–30.

**The paper presents experiments with potato comparative analysis regarding the detection or use of specific markers to measure differences between organic or conventional grown potato tubers. Protein patterns with SDS-PAGE followed by MALDI-TOF identified at least two proteins ie, patatin and or granule-bound starch synthetase 1 were induced in organic crops.

53 Terry LA, White SF and Tigwell LJ. The application of biosensors to fresh produce and the wider food industry. Journal of Agricultural and Food Chemistry 2005:53:1309–1316.

**This report assesses the current and future trend in the application of biosensor technology fresh produce and the wider food industry. Current target analysis are presented.

54 Gadani F, Bindler G, Pijnemburg H and Rossi L . Current PCR methods for the detection, identification and quantification of genetically modified organisms (GMOs): a brief review. Beitrage zur Tabakforschung International-Contributions to Tobacco Research 2000:19: 85–96.

**This article reviews the state-of-the-art of PCR-based method developments for the qualitative and quantitative determination and identification of GMOs.

55 Kelly S, Heaton K and Hoogewerff J. Tracing the geographical origin of food: the application of multi-element and multi-isotope analysis. Trends in Food Science and Technology 2005:16:555–567.

**This research presents the systematic global variations of stable hydrogen and oxygen isotope ratios in combination with elemental concentrations, including heavy isotope variations as well as other bio-geochemical indicators. A new field, "Food Forensics", is introduced to the reader.

56 Kelly SD. Using stable isotope ratio mass spectrometry in food authentication and traceability. In: Food-authenticity-and-traceability, Lees, M (Ed.). CRC Boca Raton, Florida: Woodhead Publishing;2003:156-183.

**The article discusses the use of stable IRMS in food authentication. Definition and terminology are presented, principle of operation of IRMS as well as application such as fruit juice adulteration, honey and wine. New applications to determine geographical origin of foods and new trends in this instrumental method are relevant for authenticity and traceability tools.

57 Wang N, Zhang N and Wang M. Wireless sensors in agriculture and food industry-recent development and future perspective. In: Computers and Electronics in Agriculture 2006:50:1–14.

**The authors discuss the advantages of wireless sensors and obstacles that prevent fast adoption. Future trends of this type of sensing mechanism and the technology for agricultural and food domains (environment, weather and geo-reference monitoring).

58 Kameoka T, Hashimoto A and Harada M. Sensing and information system for cultivation traceability in the farm. In: AFITA 2002: Asian-agricultural information technology and management. Proceedings of the Third Asian Conference for Information Technology in Agriculture. Beijing, China, 26–28 October 2002:421–425.

**The article reviews the development of various sensors to acquire information based on optical multi-band spectra to provide precise information on safety and quality of agricultural products (laser fluorescence). Soil moisture with infra red is also included to generate a data base and sensors for mapping.

59 Golan E, Krissoff B, Kuchler F, Calvin L, Nelson K and Price G. Traceability in the US food supply: economic theory and industry studies. In: Agricultural Economic Report. Economic Research Service, US Department of Agriculture. Economic Research Service. Report (830). Washington, DC: USA; 2004: pp 48.

http://www.ers.usda.gov/publications/aer830/

**The authors report that private sector food firms have developed substantial capacity to trace. The best targeted government policies for strengthening firms' initiatives to invest in traceability are aimed at ensuing the unsafe or falsely advertised foods are quickly removed. Possible policy tools are presented as well as a fresh produce, grains and oilseed.

60 Carantino S. RFID. Un outil prometteur encore limité par son prix. Revue Laitiere Francaise 2005:648:31–32.

**The article compares RFID new applications advantages and inconveniences as well as foreseen healthy life to master BC.

61 Anon. Les distributeurs privilégient les standards GS1. Process 2005: 1212:6.

**This article emphasises the good practicality of GS1 and criteria such as EAN 128 for pallets, EDI for data interchange, notice of shipment with SSCC, and quantity shipped by GTIN, as well as lot number.

62 Osborne A. Cracking the code. Fresh Produce Journal 2002:26:20–-21.

**The author covers BC standards and its large utilisation in grocery and retail chains. The fresh produce sector has failed to get on the wagon. With the global economy trading partners require essential information. Produce with PLU code are shown. Generally, European Union's marketing standards specify label and information. Major retailers require EAN-UCC BC on pre-packs, cases and boxes. New solution the RSS is showing interesting results.

63 Schwägele F. Traceability from a European perspective. Meat Science 2005:71:164–173.

**The paper outlines European views on traceability to feedstuff, meat and meat products, species identification, authenticity, addresses the application of biosensors and tracking technology (DNA, NMR, infrared, identification number, data carriers and electronic messages) and finally, capitalises on the importance of computer modelling and risk assessment. Some analogies can be drawn for fresh produce.

64 Smith GC, Tatum JD, Belk KE, Scanga JA, Grandin T and Sofos JN. Traceability from a US perspective. Meat Science 2005:71: 174–193.

**This article reviews the position of the US in traceability of livestock, poultry and meat. The authors compare various countries state of technology and readiness and aspects such as origin and ownership, surveillance and control, bio-security, compliance and international requirements as well as labelling. Some analogies can be drawn for fresh produce.

65 Kleist RA, Chapman TA, Sakai DA and Jarvis BS. RFID labeling – smart labeling concepts and applications for the consumer packaged goods supply chain. 1st Ed. Printronix. California, USA; 2004: pp 211.

**The writers present smart labelling as a small portion monumental in its effect but also a big change for the retail industry. Many organisations beyond Wal-Mart are requiring cases and pallets labelling for traceability and logistical efficiency. This book teaches how to stream RFID into our current BC labelling strategy. It integrates physical tags and associated electronic product code data.

66 Finkenzeller K. RFID handbook – radio-frequency identification fundamentals and applications. John Wiley and Sons, Ltd. West Sussex, UK; 1999: pp 304.

**The author introduces fundamentals and applications of RFID; different features such as Full Duplex, Half Duplex and sequential transponder construction, frequency, range and coupling, and physical principles of operating systems. Data integrity and security are detailed. Application examples with market overview close the document.

67 Palmer RC. The bar code book-reading, printing, specification, and application of bar code and other machine readable symbols. 3rd edition. Helmers Publishing Inc.: New Hampshire, USA;1995 pp 386.

**This book provides in depth information for both beginners and experienced BC users. It includes symbology, data entry techniques, standards, fundamentals of BC reading, scanners, printing as well as a glossary.

68 Ash M, Meyers RB and Kilbane D. Beginners reference guide to bar code labelling. TL Ashford Publication, Frontline Solutions: Ohio, USA; 2001: pp 51.

**This a quick reference guide to BC labelling and introduces the 10 commandments for compliance labelling, and the most useful symbology and glossary for linear and two dimensional symbology or optical character recognition.

69 Schaeffer E and Caugant M. Traçabilité-guide pratique pour l'agriculture et l'industrie alimentaire. ACTA-ACTIA. Paris, France;1998: pp 80.

**This practical guide addresses the production and processing sectors to define traceability upward and downward. Some aspect such as when, the means, or the tools as well as the methodology are described. Cases are presented for nectarines, apricots and peaches.

70 AFNOR. Traçabilité dans les filières agricoles et alimentaires-recueil normes et réglementation agroalimentaire. St-Denis de la Plaine, France;2002: pp 355.

**The AFNOR guide describes some French Standards of interest for the vegetable Cluster or File. It is referred to NF-V-01-005 for agricultural production quality management. A second standard NF-V-25-111 presents good production practice for field potato including lot and sub-lots (``parcels``) identification, fertilisation, phyto-sanitary plan and agents; as well as potato reception and preservation for the fresh market (NF-V-25-112). In the second part of the guide is a presentation of the European standard EN-1556 : 1998 on BC. It includes a second part on FD-Z-63-301 describing the guidelines on the choice and use of BC. Finally, the FD-Z-63-500 presents the automatic identification techniques, identification by radio frequency, principles and applications.

71 Viruéga JL. Traçabilité, outils, méthodes et pratiques. Éditions d'Organisation Paris, France; 2005: pp 237.

**The writer provides an overview of current concept of traceability from the 1960s to 2005. For the second part he presents methods as well as new definition and standards for traceability. Finally, traceability is viewed as a new sector by itself, as well as a new market place, a new trend and, interesting perspectives are discussed.

72 Anonymous. Whitepaper. Datamax. Full traceability for the European fruit and vegetable supply chain. Datamax: Florida, USA; 2004: pp 1–5 http:www.globalspec.com/supplier/techarticles/datamax.

**This document is about full traceability for the European fruits and vegetables supply chain. The main thrust is on the application of EAN-UCC standards for product labelling at all points of the chain. The objectives were to implant controls that can trace back, also, quickly identify, locate and facilitate recall of products. In this case the main implantation technology is BC. Different forms of information available from retail, shipping/logistic and farm/producer are presented. The food chain is truly a global one above local and regional perceptions or vision.

73 Tavernier EM. An empirical analysis of producer perceptions of traceability in organic agriculture. Renewable Agriculture and Food Systems 2004: 19:110–117.

**This study assesses producer perception of traceability in organic agriculture, using survey data from 2001. Logistic regression models were used. The results suggest that the organic producers with sales of less or under $US 50 000 are more willing to have government intervention. Biotech foods needed to be labelled to show difference from conventional ones. Some reluctance does exist in the level of confidence for this study based on the difference in perception between small and large volume sale producers.

74 Schiefer G. Traceability and certification in food quality production – a critical view. In: new approach to food-safety economics. Series: Wageningen UR Frontis Series, Vol 1, Velthuis, AGJ, Unnevehr LJ, Hogeveen H and Huirne RBM (Eds.). Springer Science and Business Media. Berlin, Germany; 2003: pp. 63–68.

**The author outlines arguments about traceability, certification in food quality production. Two views are presented: enterprise alone or as sector in the food chains in conflict with perceptions. The customers` risks perception and the experts' risks judgement must be carefully considered. The key issues being trust! Change our view on the development of market organisation towards electronic integration. The re-organisation infrastructure still needs to be done.

75 EAN. EAN International Fresh Produce Traceability Guidelines: 2001 1–33 pp. In: www.ean-int.org/agro_food_fruit_vege.html and http://www.can-trace.org/portals/0/docs/EAN_fresh_produce_traceability.pdf

http://www.gs1za.org/upload/Banana%20Traceability%20Guidelines.pdf

**The Guidelines were developed together with the Euro-Handels Institute, the European Association of Fresh Produce Working Group, the European Union of the Fruit and Vegetable Wholesale, Import and Export Trade and the Southern Hemisphere Association of Fresh Fruits Exporters. This is a voluntary adoption proposal. The aim is to provide a common approach to tracking and tracing by means of internationally accepted numbering and bar coding system-the EAN.UCC referencing system. The purpose is to have a functioning model, common tools and terms of definitions and guidelines. Other elements are detailed including bananas.

76 CPMA/PMA Fresh Produce Traceability- A Guide to Implementation. March 2005 pp. 1–47.

http://www.can-trace.org/portals/0/docs/FreshProduceTraceabilityImplementationGuide.pdf

**The Association is committed to the Canadian Traceability Task Force, best practices, piloting projects and education. It is also, one of the key collaborators to Can-Trace initiative. www.cpma.ca/industry/en/trace.asp.

77 About CAN-TRACE. It is a collaborative and open initiative committed to the development of traceability standards for all food products sold in Canada. Defines the minimum requirements base on EAN-UCC system. Who is involved? Global traceability information documents and why?

http://www.can-trace.org/HOME/tabid/36/language/en-US/Default.aspx

78 Implementing Traceability in the Food Supply Chain 2001:pp 1–107.

**A common reference document including, definitions, description of a system implementation. Also, case study, recall system and glossary.

http://www.can-trace.org/LEARNMORE/GlobalTraceability/tabid/86/Default.aspx

79 EAN International. Traceability management tools for agriculture, food and beverage products. Brussels, Belgium; 2004:1–11.

**The GS1 Traceability solution provides powerful tool kit for implementing traceability in the supply chain based on the GS1 System of standards.

http://www.ean-int.org/

http://www.ean-int.org/docs/traceability/GS1_tracebility_brochure.pdf

http://www.ean-int.org/productssolutions/traceability/implementation/

http://www.ean-int.org/docs/traceability/GS1_fresh_produce_traceability.pdf

http://www.ean-int.org/productssolutions/traceability/technical/

http://www.ean-int.org/docs/traceability/traceability_FAQ.pdf

On February 2006, GS1 launches a unique and innovative Global traceability Standard. This is the outcome of team composed of 73 industry experts in 18 countries to produce a global business agreement and generic requirements. Overview and brochure are available describing benefits. Implementation guides and guidelines are available for fresh produce.

80 Furness T and Smith IG. Emerging needs for developments in structures, techniques and standards for traceability. In: The International Review of Food Science and Technology (IUFoST). Ottaway PB (Ed). Sovereign Publishing Limited: London, UK; 2004: pp 22–23.

**The authors describe a wide range of disparate methods for identifying and managing food entities. They present the framework for FoodTrace. Action programme has revealed 11areas to improve and support traceability management. They recommend the uniformity in numbering and identification such as the EAN-UCC system, the most recognised. Other recommendations are also formulated.

81 Doyon G, Clément A, Lagimonière M, Côté P, Veilleux L and Veilleux P. Quality, safety and reliability in traceability system: a Canadian approach. In: The International Review of Food Science and Technology (IUFoST). Ottaway PB (Ed). Sovereign Publishing Limited: London, UK; 2004: pp 27–32.

**The article describes the many challenges facing the Canadian enterprises and many professionals in the various food chains. Relevant definition and terminology are explained, as well as risks management skills and perception versus real facts about quality. Reliability and failure probability are attached with the spread and speed of recalls. Components of internal manufacturing traceable information and schematic of multiple surface elements of traceability are described.

82 Moe T. Perspectives on traceability in food manufacture. Viewpoint. Trends in Food Science and Technology 1998:9:211–214.

**The author outlines the fundamental and theoretical issues of traceability system. Some interesting fundamentals and definitions, terms meaning are introduced. Advantages for the chain as well as for the internal traceability close the presentation.

83 Food Traceability Report. www.foodtraceabilityreport.com

Magazine Food Traceability Report – 155 documents on traceability of Fresh Fruits and Vegetables. (Require a member paid fee for access). The second search for fresh produce found 55 hits. Search began with the 2001 creation of the CRC Press news line up to today.

84 Vergote MH and Lecompte C. Traçabilité : Les PME agroalimentaires face à la nouvelle réglementation. In: Industries Alimentaires et Agr icoles 2005: 122:18–24.

**The purpose of the research was to create a method to estimate the tools of traceability and to examine the applied systems in food industries. Traceability audits were conducted in 2004. The case of a milling industry is performed.

85 Viruéga JL. 10 ``bonnes`` raisons pour faire de la traçabilité. In: Industries Alimentaires et Agricoles; 2005:122:26–29.

**This article provides a first track record of 5 months after the implementation of the statutory obligation to apply traceability at the European level.

86 Salat A. Traceability of fruits and vegetables, development of regulation. In: PHM Revue Horticole 2005:471:15–18.

**This article describes the importance of the directive CE 168/ 2002 in application for 2005 on the whole food chain of fresh produce. No method is proposed, only orientations. It discusses article 18, the traceability including production, processing and distribution plus importation, storage, finally, transportation. However, it does not discuss phytosanitary products, materials and objects in contact with food.