Traceability in the Food Chain

A preliminary study

Food Chain Strategy Division, Food Standards Agency

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Executive summary

- The Food Standards Agency needs an overview of traceability in order to come to a view with regard to the role of traceability systems both in connection with food safety and also to protect other interests of consumers in relation to food.

- The EU General Food Law Regulation defines traceability as “the ability to trace and follow a food, feed, food-producing animal or substance … through all stages of production, processing and distribution”.

Consumer interest

- Consumers gain mostly hidden benefits from traceability *i.e.* more effective achievement of food safety and an increased effectiveness of recall in emergencies.

- Traceability also has a role to play in promotion of informed consumer choice because it offers the potential to verify label information on product and ingredient history.

Legal requirements

- There are some requirements in legislation for traceability. However, the most complete mandatory traceability system enables beef on sale within the EU to be traced back to the county of birth.

- However, the EU General Food Law Regulation contains requirements for traceability in the food chain. The implications of the implementation and enforcement of this proposed legislation in all sectors of the food chain were a key motivation for this study.

Characteristics of traceability systems

- The basic characteristics of traceability systems are:
  - identification of units/batches of all ingredients and products,
  - information on when and where they are moved or transformed
  - a system linking these data.

- In practice, traceability systems are record keeping procedures that show the path of a particular unit or batch of product or ingredient from supplier(s), through all the intermediate steps which process and combine ingredients into new products and through the supply chain to customers and perhaps ultimately to consumers.

- Simple hand-written or printed labels are being rapidly replaced or supplemented by machine-readable identification, e.g. bar codes and radio frequency tags. The amount of information that can be carried by identification systems has also been increasing rapidly; many systems can now carry > 2000 characters of information. This has implications for enhancing the operation of traceability systems.

- Traceability systems are critically reliant on the recording of information. How much information is carried in a traceability system varies and is dependent on the nature of the product, on farm and manufacturing practice, customer specifications and requirements in law.

- Robust mechanisms are needed to facilitate the collection and authentication of any information, to enable it to be updated and shared through the chain. In some cases, analytical tests may be able to support and check traceability systems.

Assessment of current systems

- There is a range of systems for traceability in place from paper-based to IT enabled. However, the increased efficiency, effectiveness and security of IT enabled systems are recognised and they are being slowly rolled out throughout the food chain.

- Partly as a result of legislation in this area, systems to deliver traceability in the livestock sector, particularly beef, are relatively advanced. This has also led to the development of protocols for electronic identification and data transfer, which may apply to all livestock sectors in the medium term.

- The diversity of food processing operations means that the way in which traceability records are kept by any business is practically unique and businesses make individual and widely varying decisions with regard to the size of batches that are produced, and hence the size of any recall.

- Throughout the food supply chains of the major retailers, traceability systems have been put in place, which are regularly independently audited by challenge to the system and judged according to goal-based requirements for speed and effectiveness of recall.

- However in other sectors, *e.g.* Foodservice, few initiatives have been taken to develop and implement robust traceability systems, or in some cases any batch traceability at all.

- Except in a few instances (*e.g.* beef and some retailer chains), frameworks are not in place linking entire food chains. Traceability is delivered through a sequential interrogation of customer-supplier links up or down the chain. There is an EU project in place (FoodTracE), which is seeking to develop a simple framework to achieve connectivity between the steps of the food chain.

- The cost of implementation of traceability systems is likely to vary enormously between business and sectors depending on the type of technology adopted, the amount of information required to be stored and the complexity of the food chain.

- In the light of this report and subsequent discussion, the Agency will assess its priorities and objectives for traceability in the food chain, working with stakeholders where appropriate.

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Useful websites

www.agmed.org.uk
www.aim-uk.org.uk
www.braidgrove.co.uk/elite.html
www.bpic.co.uk/erp.htm
www.biopsytec.com
www.cattlecontroller.co.uk
www.defra.gov.uk/animalh/tracing
www.e-centre.org.uk
www.eurovetlivestocktracing.com
www.i-label.net
www.indexsystems.co.uk
www.intentia.com
www.kaicorporation.com
www.omron.co.uk
www.qualtrace.com
www.qsa.co.uk
www.trolleyscan.com
www.ukasta.org.uk
www.whatman.co.uk

Purpose and approach of the study

1. Traceability has become a ‘buzz word’ with regard to food, particularly following a number of food safety incidents during which traceability systems have been shown to be weak or absent and hence slow or unable to assure consumers of food safety *e.g.* dioxins in animal feedstuffs in Belgium and ‘unfit poultry meat’. The foot and mouth disease epidemic in the UK in 2001 also highlighted the large number of livestock movements taking place and the comparative difficulty of tracing sheep movements.
2. The Food Standards Agency needs an overview of traceability in all its aspects in order to come to a view with regard to the role of traceability systems both in connection with food safety and also to protect the interests of consumers in relation to food. This study carried out by the Food Chain Strategy Division aimed to bring together all aspects of traceability throughout the food chain in a preliminary report. Further work is on-going to assess the priorities and objectives for the Agency with regard to traceability in the food chain, with all relevant colleagues and stakeholders where appropriate.
3. This report therefore comprises an account of:
    - definitions of traceability for the food chain;
    - current and impending legislation;
    - interests of consumers and the industry;
    - characteristics of traceability systems;
    - identification, information and the links between them;
    - verification of traceability systems; and
    - examples of traceability systems operating in various sectors.
4. The preparation of this report follows:
    - meetings with Agency colleagues to establish the background interest in traceability systems, to frame the work plan of the project and to identify any contacts already in place within the industry.
    - meetings/visits with those applying traceability systems in various sectors throughout the food chain and those involved in the development of improved technology with relevance to traceability.

What is traceability?

5. Traceability is the ability to trace the history, application or location of an entity by means of recorded information (ISO 8402:1994).
6. Traceability can be considered in four distinct contexts and in each it has a slightly different application:
    - *for products*: it creates a link between materials, their origin and processing, distribution and location after delivery.
    - *for data*: it relates the calculations and data generated through a quality loop and may link these back to the requirements for quality.
    - *in calibration*: it relates measuring equipment to national, international or primary standards, to basic physical constants or properties or to reference materials.
    - *in IT and programming*: it relates design and implementation processes back to the requirements for a system.
7. For analytical laboratories, demonstrating traceability, so that any measurement can be related to stated references, usually national or international standards, through an unbroken chain of comparisons all having stated uncertainties, is critical to laboratory accreditation e.g. to EN45001 Standards. For some measurements made on foods and feedstuffs e.g. pesticide residues, standard materials can be relatively easily obtained. However in other cases, e.g. with regard to mycotoxins, standard materials may be more difficult to define/maintain, and hence the calibration and validity of these measurements is more difficult to demonstrate by traceability. In calibration, traceability is not a meaningful end in itself but is a component of a quality assurance system for measurement. Traceability within an analytical context will not be covered further in this report.
8. Traceability of products and data are important for the consideration of advanced traceability systems relating to products and their processing and it is these concepts that we will consider in more detail in relation to the food chain in the remainder of this report.
9. Within a production chain it is possible to identify at least two levels of traceability:

- Internal traceability i.e. traceability within one link or business within the chain. Internal traceability allows data about raw materials and processes within the business to be linked to the final product separately in each stage of production, processing or distribution.
- Chain traceability i.e. traceability between links in the chain. The focus is on information which accompanies the product from one link in the chain to the next to extend traceability for any product through all stages of production, processing and distribution.

What is traceability in the food chain?

10. In the food chain, traceability means the ability to trace and follow a food, feed, food-producing animal or substance through all stages of production and distribution. Stages of production and distribution means any stage including import, from and including the primary production of food, up to and including its sale or supply to the final consumer and, where relevant to food safety, the production, manufacture and distribution of feed[1].
11. Many manufacturing systems, including food manufacturing, have sought registration to the ISO 9001 Quality Standards. These require that the product should be able to be traced from the current stage back through all its stages of manufacture through accurate and timely record-keeping. The requirement for paper documentation has recently been changed; computer records solely can now be used as evidence of compliance.
12. In primary production, traceability has been defined as the ability to trace the history of the product through the supply chain to or from the place and time of production, including the identification of the inputs used and production operations undertaken (British Standards Institute PAS 85:2000). Legislation has been recently introduced to ensure livestock identification and the tracking of livestock movements. Many of the farm assurance schemes require some level of traceability to be in place within primary production.

[1] Definitions at Article 3, EU General Food Law Regulation.

Legislation

Current legislation

13. There is currently no general legal requirement for the establishment of traceability systems in the food chain. However, some limited traceability is required under a number of separate measures.
14. The British Cattle Movement Service (BCMS) an Agency of DEFRA, runs the mandatory cattle identification and registration scheme in the UK. All cattle must be registered and those born after 1 January 1998 have their movements traced from birth to death. (Further details are given in paragraphs 101-103).
15. The Compulsory Beef Labelling Scheme (CBLS) came into operation in the UK on 1 September 2000. Mandatory labelling requirements at the point of sale require the identification of both the slaughterhouse and cutting plant(s) for fresh and frozen beef, including mince and uncooked beef burger patty with no added ingredients. Additional labelling requirements (countries where born and raised) became compulsory on 1 January 2002. (Further details of the CBLS are given in paragraphs 108-112).
16. The Food Premises (Registration) Regulations, 1991 (modified by subsequent amendments) require all food businesses to be (at least) registered The Local Authority holds details of the location and business type on a register. In addition, certain premises must comply with certain structural and operating standards: including slaughterhouses, cutting plants, game handling establishments, establishments producing minced meat, meat preparations and mechanically separated meat, establishments manufacturing meat products and wholesale markets where unprocessed or processed products of animal origin are handled. These are inspected before they can open and approved/licensed by the Competent Authority. Businesses manufacturing particular feed additives and feed businesses using such additives also need to be approved or registered. Such businesses are issued an approval/registration code by the food authority.
17. A health mark is required for consignments of food of animal origin: meat, meat products, minced meat and meat preparations, wild-game meat milk and milk-based products, egg products, fish and shellfish. The Health Mark is an oval (EU),

square (national) or pentagonal (wild game) stamp containing the approval number of the premises. In the case of meat and meat products this must currently be applied by the Official Veterinary Surgeon (OVS) or under their supervision. For packaged meat and offal the health mark is printed on a label which is visible to the outer surface of the package but is destroyed if the package is opened.

18. The General Product Safety Regulations (1994), which implement Directive 1992/59/EEC, impose requirements concerning the safety of products (including food and drink) intended for, or likely to be used by, consumers. This Regulation includes a requirement for systems to be in place that enable product to be withdrawn from sale, where a problem that might affect consumer safety is reported.
19. The Food Lot Marking Regulations (1996) apply to the sale of all foodstuffs for human consumption and continue to implement EC Directive 89/396/EEC, which established a common framework for a lot/batch identification system throughout the EU to facilitate tracing and identification of products through the food chain. The lot marking indication must appear in such a way as to be easily visible, clearly legible and indelible. The producer, manufacturer, packer or first seller within the EC determines the size of any lot. Some categories of sales and sales units are exempt including agricultural products which are delivered for immediate processing or packaging, bread baked on the premises for direct sale, individual items of food which are not pre-packed when offered for sale (loose fruit, vegetables, sweets). A “sell by” or “use by” date on the labelling of the product may be used as a lot mark.
20. The Feeding Stuffs Regulations 2000, which implement various EC directives, place controls on the marketing of feed materials (ingredients or single feeds). These requires that a label must be attached to, or travel with, the batch of feed material. The label must contain the name and address of the person responsible for the information and other statutory information relating to composition. In addition where the feed material is part of a divided batch the label must contain a reference to the original batch. For sales of feed materials from farms, the batch is considered to enter the feed chain at the premises of the crusher, central store or feed compounder. A label is then generated when the grain is sold on, whether as a

straight or as part of a compound (manufactured) feed. No label or batch reference therefore required to be generated on-farm.

21. There are also labelling requirements for compound feedingstuffs, feed additives and premixtures (mixtures of additives with a carrier) These cover provisions to include the details of the person responsible for the labelling information.
22. Other Regulations require establishments and intermediaries manufacturing or using certain feed additives (e.g. vitamins and trace elements) to be approved or registered. This includes manufacturers of compound feeds and farmers who buy-in compound feeds with additives. The Regulations specify minimum conditions that must be fulfilled including records of suppliers and customers. There are similar requirements concerning premises producing feedingstuffs containing zootechnical additives (e.g. antibiotics or growth promoters).
23. The Materials and Articles in Contact with Food Regulations 1987 also provide a basic form of traceability for finished items intended to come into contact with food, but which are not already in contact with food when sold at retail or otherwise. The regulations provide that the items shall be shown with either the name or trade name and address or registered office or the registered trademark of the manufacturer or processor of the item, or of a seller of the item established in the European Community. These requirements are common throughout the European Union.
24. Food sold to the final consumer or mass caterer, which contains GM material (i.e. protein or DNA from a genetically modified organism) is required to carry a label, to indicate this. UK retailers claim to have developed identity preservation systems to segregate non-GM crops (maize, soya) in the supply chain to support labelling claims such as ‘non GM’.
25. The Food Irradiation Provisions (England) Regulations 2000 require that irradiation plants keep records for each batch of food irradiated. Irradiated food has to be labelled and accompanied by documentation and/or identification that identifies the facility where it was irradiated.
26. EC Commission Regulation 2065/2001 lays down detailed rules relating to consumer information and labelling for fish and fish products sold at retail. The new rules apply from 1 January 2002, although enforcement provisions in the UK are

subject to consultation until 7 May 2002. These provisions require all chilled, frozen and smoked fish or fillets and shellfish, when offered for retail sale to the final consumer to be labelled with: the commercial designation of the species; method of production (caught at sea, in inland waters or farmed) and the catch area (e.g. Pacific) or country of production if farmed. The Regulation requires that the labelling information, as well as the scientific name of the species, is given at each stage of the marketing chain. This information can be given by labelling or on packaging, or by means of commercial documents accompanying the product. In the UK it is generally understood that commercial documentation (e.g. sales note, invoice) is the usual means of providing this information through the chain.

Impending legislation

27. The difficulties encountered in tracing where dioxin-contaminated animal feed had been used and the complex interactions and implications within the food chain of such contamination raised the profile of traceability at an EU level. Shortly afterwards the European Commission's White Paper on Food Safety stated:

28. *A successful food policy demands the traceability of feed and food and their ingredients. Adequate procedures to facilitate such traceability must be introduced. These include the obligation for feed and food businesses to ensure that adequate procedures are in place to withdraw food and feed from the market where a risk to the health of the consumer is posed. Operators should also keep records of suppliers of raw materials and ingredients so that the source of a problem can be identified.*

Revised General Product Safety Directive (GPSD)

29. Separately to measures related to food law, a revised General Product Safety Directive (2001/95/EC) which contains traceability requirements for products (including food) was adopted by the European Parliament and Council in October 2001, and member states are required to implement this with effect from January 15 2004. This Directive will impose new obligations on food producers and distributors, to ensure that food products can be traced back to their point of production, but will not extend to the ingredients used in that product. Thus the revised GPSD will

effectively bring in part of the requirements in the General Food Law Regulation (see below) one year in advance.

EU General Food Law Regulation

30. The EU General Food Law Regulation (178/2002) contains clear requirements for traceability, stating at Article 18:

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

31. This general traceability requirement is non-prescriptive but encompasses all food and feed business operators including primary producers. Retailers of goods to the final consumer are exempt from the requirements of forward traceability.

32. This legislation does not, however, include any requirement for records to be kept identifying how batches are split and combined within businesses to create particular products i.e. it does not require complete internal traceability. It will also not be possible to identify the bulking up of ingredients from a number of suppliers or the origin of the components of any batch. The legislation relies on a one up, one down approach between businesses to create chain traceability; the robustness of such a system has not been tested.

33. However, more specific requirements currently applying to individual sectors or products are not replaced by this legislation. The development of future sector specific rules under comitology procedure is also possible.

34. The Regulation came into force on 21 February 2002. Certain provisions (including Article 18) will not apply until 1 January 2005. This will further strengthen the legislative requirements relating to traceability by ensuring that some minimum record keeping is in place in all food businesses. The Regulatory Impact Assessment (RIA) carried out for this proposal suggested that implementation of this requirement is likely to result in minimal or no cost to businesses as most businesses will have some sort of system in place which would meet the basic requirements.

Draft EU Consolidated Hygiene Regulation

35. The draft consolidated hygiene regulation would require that food business operators ensure that all businesses under their control are registered or approved with the Competent Authority, as currently. This would also be extended to include primary producers (farms, fisheries, etc). Under the proposal each business would be allocated a registration number, where the registration, or approval number, is used to identify the foodstuffs that it produces. This number would need to accompany the foodstuff through the food chain, other than at retail level. Although at an early stage of negotiation, this identification requirement would further strengthen the legislative requirements related to traceability.

36. Changes in the hygiene regulations relating to slaughter are likely to require a link to be established between the animal presented for slaughter and its on-farm history. Information about each animal (likely to be based on exception reporting) will be required by the OVS (and team) at the slaughterhouse before it can be killed.

GMOs

37. There are currently on-going discussions in Brussels on EU Commission proposals to extend the authorisation and labelling rules for GM food and feed and to require traceability and labelling of GMOs and products derived from them. Traceability is proposed both to facilitate full product labelling and to enable withdrawal if adverse health effects are identified. This proposal would extend the general requirements

for traceability in the General Food Law Regulation by requiring the transmission of specific information (either that the product contains or consists of GMOs or that it is a product of GMOs) with the product along the food chain, which would require batch traceability in many cases. As a result, initial estimates suggest that the implementation of traceability as required in this proposal would be relatively costly to the industry.

38. The verification of the information transmitted within a traceability system, particularly where the product is produced from GMOs and no analytic methods can distinguish it, provides the greatest difficulty for the implementation and enforcement of such proposals. In fact the mandatory requirement of such a system would create immense practical difficulties for enforcement, such that the requirement as described above may be regarded as practically unenforceable. Where traceability includes commodity crops grown in developing countries, there are specific problems and impacts, which need to be considered. Many farmers in these countries are illiterate and paper based audit trails can easily break down.

Animal Feed

39. The European Commission is currently working on proposals to extend approval requirements, including to manufacturers of certain feed materials, to improve current traceability levels and identification of critical control points, and to establish a code of good manufacturing practice for animal feeding. Proposals are likely to be issued late in 2002.

Interests of stakeholders

Consumers

40. Traceability systems are of interest to consumers, as part of systems which:
    - Protect food safety by effective product recall, in the case of an emergency.
    - Enable avoidance of specific foods and food ingredients easily, whether because of allergenicity, food intolerance or lifestyle choice.
    - Enable real choice to be exercised between food produced in different ways.

41. Consumers gain mostly hidden benefits from most traceability systems *i.e.* more effective achievement of food safety and an increased effectiveness of recall and

speed of information in the case of emergencies. Traceability systems are perceived by consumers to give more control within the food chain, which should deliver safer food and perhaps food of better quality as well. *"Basically it is known where what you are eating has been and that any problems can be traced back and sorted out."*

42. However, consumer interest in how food is produced and where it is produced is increasing and an increasing proportion of the population is seeking to avoid particular ingredients (*e.g.* allergens, GM). Consumers regularly check the list of ingredients, if they have allergies, food intolerances or wish to avoid additives. A minority of customers also looks for organic, GM free, free range, fair trade and vegetarian foods. Most concern about origin is expressed with regard to meat and its products (MORI research study for MAFF, 2000).
43. When eating out, consumers require less information. However, the information requirements in the Foodservice sector include the ingredients of dishes (related to allergies, food intolerance, vegetarianism), the size of portions, presence of GM ingredients, from what ingredients the food is prepared (*e.g.* fresh, frozen, tinned), and the presence of additives (MORI research study for FSA September 2000).
44. Traceability may therefore form part of an effective system that provides information about all stages of production and distribution for any food. Traceability therefore may support the customer's right to know where food comes from, giving consumers greater choice and enabling them to make decisions about whether to buy food products or not (MORI research study for MAFF, 2000).
45. These two roles for traceability often seem to be muddled in public perception e.g. "Consumers will be safer in that they will be able to see detailed information about where the meat comes from, not only the country of origin but also the individual farm". The provision of knowledge of origin direct to the consumer does not make them safer. The maintenance of a verifiable and robust traceability system means that consumer safety is likely to be increased in the event of an emergency. However, such a system does not require the knowledge to be passed on to the consumer. The provision of knowledge through traceability is more clearly linked to an increase in consumer choice based on product identity and origin. Consumers

are likely to gain confidence in food safety from assurances of traceability and supporting withdrawal systems, which may be reinforced if this information is provided on-label.

Government

46. Traceability systems are of interest to government as part of systems which:
    - Protect public health through the withdrawal of food product from sale
    - Help to prevent fraud where analysis cannot be used for authenticity *e.g.* free-range eggs, organic food
    - Control zoonotic disease e.g. tuberculosis, salmonellosis, bovine spongiform encephalopathy
    - Enable control with regard to human and animal health in emergencies *e.g.* contamination of land or raw material
    - Control epizootic and enzootic livestock diseases through the rapid identification of disease sources and dangerous contacts.
    - Monitor /control livestock numbers for subsidy claims
47. While the primary role of traceability is to protect public health by facilitating the rapid withdrawal of products from sale, increasingly traceability systems are being developed to carry mandatory information about products forward through the food chain and also to provide support to label claims with regard to product origin. These two roles of traceability systems are likely to require different approaches (or at least different emphases) in verification.
48. Where mandatory traceability systems are put in place, they need to be achievable for all businesses. However, opportunity also exists to foster the uptake of improved practice by support of industry guidelines e.g. through voluntary certification and assurance schemes.

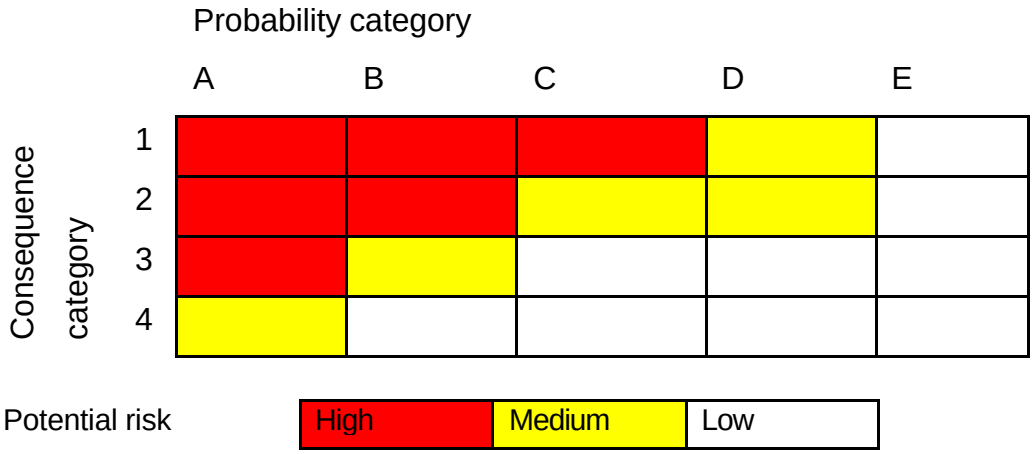
Industry

49. Traceability systems are part of systems which enable industry:
    - To comply with relevant legislation
    - To be able to take prompt action to remove products from sale and protect brand reputation (through a failure in product quality or food safety incident)

- To minimise the size of any withdrawal and hence the costs incurred in recovering, disposing or reconditioning products already placed on the market.
- To diagnose problems in production and pass on liability where relevant.
- To create identity preserved non-GM sources of soya and other ingredients.
- To minimise the spread of any contagious disease amongst livestock.
- To protect the food chain against the effects of animal disease.
- To assure meat and meat products and maintain markets and consumer confidence.
- To create differentiated products in the market place because of the way they have been produced.

50. The implementation/upgrading of traceability systems within the industry may occur with changes in process control systems (as the size of the processing operation outgrows the current manual systems). Customers may require the delivery of goods into warehouses operating with standard barcodes *etc.* hence requiring the purchase of bar code printing and reading equipment. Traceability may also be delivered as a side-effect of increasing efficiency in enterprise resource planning (ERP) within businesses and supply chain management between them, including better integration of electronic data interchange and efficient consumer response (ECR) systems.
51. Results of studies in the US show significant loss in company value (and shareholder losses) when companies are implicated in a recall involving serious food safety hazards. Where less serious hazards are involved e.g. mislabelling, there was no evidence of an implication for stock value. Decisions relating to the implementation of traceability systems are therefore often made with reference to business risk and to protect brand value. The probability of an incident occurring and its consequences may be assessed using a risk matrix, e.g. Figure 1.

Figure 1 Example of a risk matrix to guide decisions relating to the implementation of traceability



	Consequence category Quality and hygiene parameters		Probability category
1	Customer fatality Lose a major customer Product recall via press Malicious contamination/ extortion	A	Possibility of repeated incidents
2	Lose a minor customer Unsatisfactory customer audit External audit non-compliance Major contamination Customer ill-health Infestation of product/premises	B	Possibility of isolated incidents
3	Multiple retail complaints Many industrial complaints Local authority investigation Minor product contamination Low hygiene audit score	C	Possibility of occurring sometime
4	Individual retail complaint Product out of specification Non-compliance Moderate hygiene audit score	D	Not likely to occur
		E	Practically impossible

52. Increasingly the cost of food safety incidents (and even scares) is being passed along the food chain (*e.g.* Taco Bell and StarLink corn). This may lead to the development of a market for insurance. Insurers are likely to create a further driver for the improvement of traceability systems in industry to minimise the risk that they carry.
53. In the retail sector, the requirements of a 'due diligence' defence under the Food Safety Act, have been translated into an increased emphasis on quality and traceability of ingredients in own-label products. Consequently many of the operating standards set for use in the industry and independently verified contain requirements for traceability and product recall procedures – e.g. British Retail Consortium (BRC), British Meat Manufacturers Association (BMMA). In addition all ISO standards have requirement for documented traceability. There is a lot of overlap between different sets of standards but each also has their own particular emphasis. The requirements imposed by their customers, particularly retailers, are usually much more stringent than the legal requirements relating to traceability in the food industry.

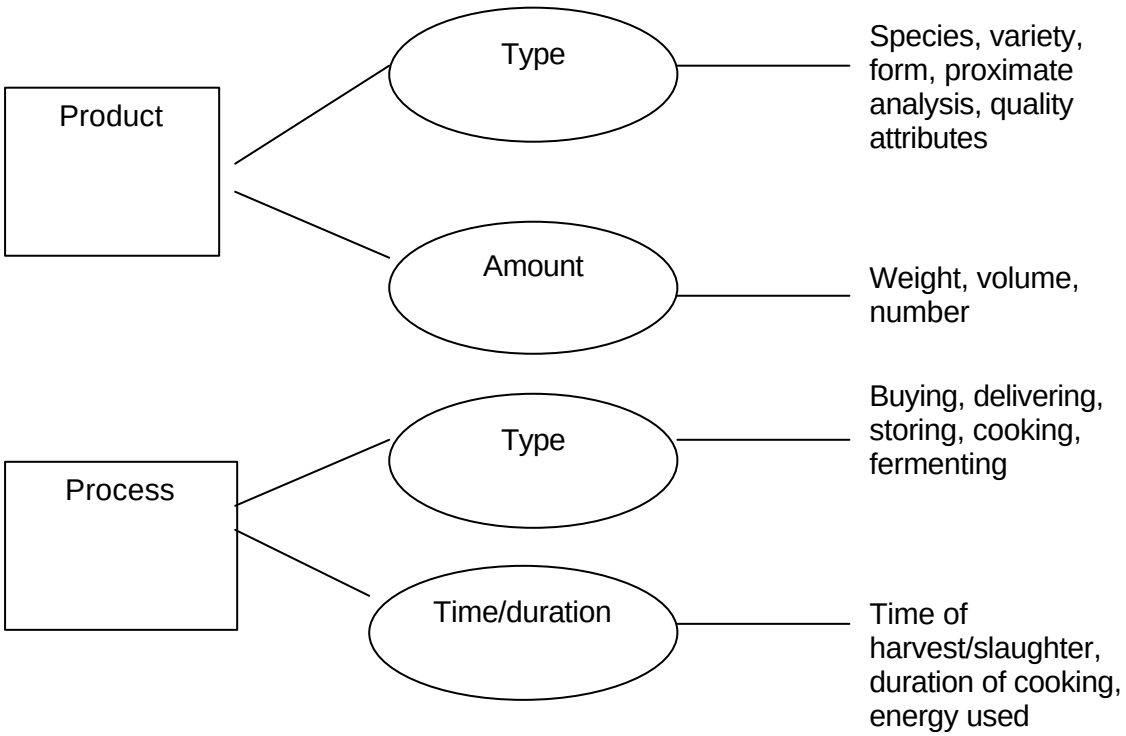
Characteristics of traceability systems

54. The basic characteristics of traceability systems, *i.e.* identification, information and the links between, are common in all systems independent of the type of product, production and control system that are served. In practice, traceability systems are record keeping procedures that show the path of a particular product or ingredient from supplier(s) into the business, through all the intermediate steps which process and combine ingredients into new products and through the supply chain to consumers.
55. The traceability of products is based on the ability to identify them uniquely at any point in the supply chain. The manufacturer or importer determines the size of a batch, which is identified uniquely. Throughout the food chain, new identities are constantly created as ingredients are combined in recipes, goods are bulked up for delivery, and/or large batches split to a number of destinations. Traceability requires both that the batch can be identified and that this identification gives a link to the product history.

56. Both products and processes may form key components (known technically as core entities) in a traceability system with information stored in relation to each (Figure 2). In the simplest systems, the only information carried is that showing the linked path along which products can be identified through the chain of manufacture, distribution and retail (*i.e.* information on the identity of the components, where they have been and when).

57. Additional information may be carried *e.g.* information enabling processing efficiencies to be calculated for manufacturing systems, information concerning ingredient quality or origin. The amount and type of information can be extended as required by the system, and it may be carried for only part of, or throughout the whole, food chain.

Figure 2 The basic components of a traceability system[2]



[2] Moe T. 1998. Perspectives on traceability in food manufacture *Trends in Food Science and Technology*, **9**, 2111-214

Identification

58. The basis of all supply chain technology is the ability to identify the things that move: pallets, packages, and units of product. The simplest type of identification is a label with a name or number written on it. However, machine readable labels are being rapidly developed by the industry so that goods can be scanned in and out of suppliers, warehouses, and customers in order to:
    - Speed up handling and reduce errors introduced through paper records or manual data entry
    - Track movements and improve logistics
    - Reconcile orders and shipments without excessive paperwork and/or manual data entry into computer systems
    - Set up electronic ordering and payment systems which reduce errors and increase efficiency
59. Automatic identification and data capture technologies (AIDC) have been developing rapidly and are widely applied in all industries. In its simplest form the identification may be a numeric or alphanumeric string in read-only format which gives access to data stored elsewhere (a licence-plate). However, the amount of information that can be carried within the identification system has been expanding rapidly; many optical systems can now carry more than 2000 characters of information, while magnetic and electronic identification systems can store up to 64K of information (equivalent to a moderately complex spreadsheet).

Optical systems

60. **Bar codes** are optical, machine-readable systems using a simple coding system with different thicknesses of bars and spaces. Scanners read bar codes by using red light to recognise the contrast between the bars and spaces of the symbol. The size and print quality of the code is critical to ensure that it is readable; the light margins around bar codes are also vital so that the scanner can establish the background reflectance and hence identify the bar code itself.
61. Standard identification systems for goods and bar coding standards have been introduced across the EU and are now harmonised across the world. The EAN.UCC system currently defines six standard numbering structures: global trade

identification numbers, serial shipping container codes, global location numbers, global returnable asset identifiers, global individual asset identifier and global service relation numbers. These numbers contain no information about the item or entity but provide a key to information stored on a database.

62. **EAN/13** The reader converts the four different thicknesses of bar and space into a 13 digit code that a computer looks up against a database. The EAN.UCC global identification numbers usually used for this code are unique and unambiguous, and identify the product. Such bar codes are used for most point of sale applications and are linked to a database containing information relating to price.
63. **UCC/EAN-128** This is similar to the EAN-13 symbol in that it has four different thicknesses of bar and space. However, EAN-128 bar codes are extended and can represent the identification number and extra information about the item in one single bar code by concatenation, using application identifiers defined by agreed standards. The most common extra information carried includes combinations of the identification numbers of trade units, use by and best before dates, lot and batch numbers and the serial numbers for transport units. These symbols cannot be scanned at point of sale and are widely used in logistics management applications.
64. **Portable data files (PDF)** These can carry a lot more information than simple bar codes and may be used where access to a remote database is not possible. The PDF file is like a number of ‘cut-down’ bar codes stacked on top of one another. Matrix codes use a pattern of filled and unfilled spaces to represent binary data, so that the impression is of a square filled with a pattern of dots. The PDF417 standard can encode more than a kilobyte of data (roughly the equivalent of an A4 page of text) in machine-readable code the size of a postage stamp. Print quality is even more important for these codes than linear bar codes and due to their complexity they are usually read using image capture techniques, in which the complete symbol image is captured, analysed by image processing and decoded by software within the scanner.

Radio Frequency Identification systems

65. Radio frequency identification (RFID) covers a range of data carrying technologies, for which transfer of data from the identifier to the reader is achieved by a radio-

frequency link[3]. RFID operates on 4 principal frequencies 135 kHz, 13.56 MHz, 915 MHz and 2.45 GHz. International standards for the use of RFID systems are being put into place, but are not as developed as those for barcodes. Lack of such standards handicaps the roll out of these identification systems on a large scale.

66. RFID identifiers (transponders) consist of a surface/chip, which can be attached onto or implanted into any surface, to provide encoded information of identity (and possibly also include additional information). A reader is also required, which may also be capable of writing data to the transponders.

67. **Passive systems** are activated by a remote energy source. The RFID then transmits its stored information, which can be detected by an appropriate recorder. The read range of these systems is around 1 m dependent on frequency and they have very limited data carrying capacity, so they are most commonly used as simple carriers of 'licence plate' identification. Passive systems have a very long life; it is more likely that the recording system will become obsolete than the RFID will reach the end of its life span.

68. Passive RFID systems cost between 25p and 75p depending on their sophistication and can be incorporated into the plastic of multi-use transport trays, ear tags or labels during manufacture. Passive systems are currently used in logistics management for clothes, airline baggage and white goods. Records of number of trips and contents are maintained with the unit for cylinders in gas supply by BOC and keg life by breweries using such systems.

69. Any group of separate RFID passive systems can be activated by the same energy source and read at the same time (known as anti collision) with up to 1000 separate tags within the field, removing the need for individual scanning of barcodes or reading of other identification numbers.

70. **Active systems** contain their own energy source. When they are activated by a remote signal, the internal power source then used to broadcast the stored information. They have greater storage capacity than passive systems, up to 2K of

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[3] Furness, A. (2000). Understanding RFID. A guide to radio-frequency identification technologies and applications. Vicarage Publications Ltd, Halifax.

information (the equivalent of several pages of text) and a greater read range. The expected life span of the energy source is 6-10 years depending on the number of accesses. Active systems are physically bigger than passive systems and more expensive. They are currently only in use in high-cost logistics operations e.g. asset tracking, pallet marking of high value goods.

Feature identification systems

71. Feature identification relies on collecting intrinsic data about an item from its natural features or properties, which can be used to provide a unique (or near unique) form of identification.

72. **The vascular pattern of the retina** is present from birth to death and unique to each animal. An image of this pattern can be simply and rapidly captured using a specially configured digital camera. **Iris scans**, which are also unique can be captured similarly. The images can be converted to a unique record for each animal, which can be stored on a database and linked to other information in the same way an identification tag is currently used. Such a system may not be more costly than implementing RFID identification for livestock and is permanent and secure.

73. **DNA** samples can be collected from animals at any point during their life cycle from blood, meat, hair, saliva etc. Storage, purification and analysis steps are different depending on the type of sample collected and the methods used for collection and storage. For cattle the analysis of the DNA (genetic fingerprint) gives an almost unique identification (DNA from identical twins would be the same). Where a database of genetic fingerprints is held, DNA can be used to identify the animal, from which meat originated, even after death. Developments are currently being put in place to facilitate the extraction and purification of DNA from heat-treated (cooked) meats. In minced meat samples from a number of animals, DNA analysis allows the individuals present to be resolved. An example of a DNA supported traceability systems is given in paragraphs 113-116.

74. The costs of DNA analysis are falling all the time and developments of more specific marker systems for livestock traceability based on single nucleotide polymorphisms (SNP), if successful, will increase the speed and reduce the cost of analysis further. DNA-based systems have the potential to work in other livestock sectors and even

for plants. However, the resolution of the method in these systems is not so clear, since more multiple births (sheep) and cloning (crops) occurs.

75. **Optical signatures** can now be coded into plastics during manufacture. These can be read using a fluorescent reader. A reading taken anywhere on the bag will give the same unique identification reading. **Chemical signatures** can also be used in a similar way and electronic noses have been developed which may allow volatile signatures to be used. For artificial materials including packaging this may give the same unique traceability as DNA. However, this technology is still in relatively early stages of development and is very high cost at present.

Information stored/carried with each component

76. Traceability requires that for each key component of the system, information is recorded describing the identity of any ingredients, where they have been and when. Where a traceability system is in place to facilitate recall, the 24 hour contact details for customers and suppliers are equally critical.
77. However, it is the supply of additional information through the traceability chain that enables many of the advantages to industry already discussed to be realised. *e.g.* the diagnosis of problems of food safety or quality back to source so that they can be remedied effectively; or, the creation of products differentiated in the marketplace because of the way that they have been produced.
78. Consumers also need information through the chain about ingredients so that they can be enabled to make choices e.g. with regard to allergens. This may repeat or supplement the information usually produced on labels and give a consumer greater access to information relating to specific foods or ingredients so that they are facilitated in their choice. The requirement for a chain of information needs traceability to be in place, though not necessarily on a batch by batch basis. Information may be held in a relatively static system, which is linked to the product by its EAN.UCC global identification numbers rather than on an individual batch basis.
79. Where there is clear agreement throughout the industry on the amount and standard of information that needs to be provided through the chain, as has taken place with regard to labelling, information sharing is facilitated without any threat to competitive

relationships. A central data storage point may facilitate the retrieval of such information much more quickly. However, such central product databases are not easy to establish. If the information is held centrally, questions arise relating to who has the responsibility (and liability) for the information. The data stored is likely to remain the 'property' of the manufacturer who supplied it, who maintains the responsibility for ensuring that information is kept up to date. There is such a database operating to support on-line shopping with the major retailers and there is also an on-going project to set up a similar system in the Foodservice sector. Whilst such a central database and the information that is stored is unlikely to be regulated by legislation, the collection and standardisation of information stored, which supplements minimum legal requirements, could be facilitated by government advice/presentation of best practice.

80. However, of equal importance are the mechanisms, which are put in place:
    - to facilitate the collection and authentication of the information from manufacturers, importers and processors;
    - to enable the information to be shared through the chain;
    - to keep the information up to date.

    The information taken out of such a system can only be as good as information entered. The verification of information carried through the food chain in this way is a critical issue, which will be discussed in detail in a later section.

Linking identification and information

81. Product withdrawal and recall systems only require traceability in part of the chain from the production step to the consumer. However, if the problem stems from the raw material, traceability back to the supplier improves the possibility of correcting fault, avoiding recurrence and/or placing the responsibility (and liability) there. So traceability usually functions both forwards and backwards through the chain.
82. There is currently a large gap between the strict quality and traceability standards applied to pharmaceuticals (e.g Food and Drug Administration requirements) and those applied in the food industry. However, the industry believes that in many

sectors of food manufacturing this gap will close, through the application of technology in process and quality control from the pharmaceutical industry.

83. In much of the food industry much work has recently been done to develop customer/supplier relationships and create assured chains of supply. However, given that unforeseen events can always happen, traceability systems are still in place even where strong customer/supplier relationships exist.

Within a business – process traceability

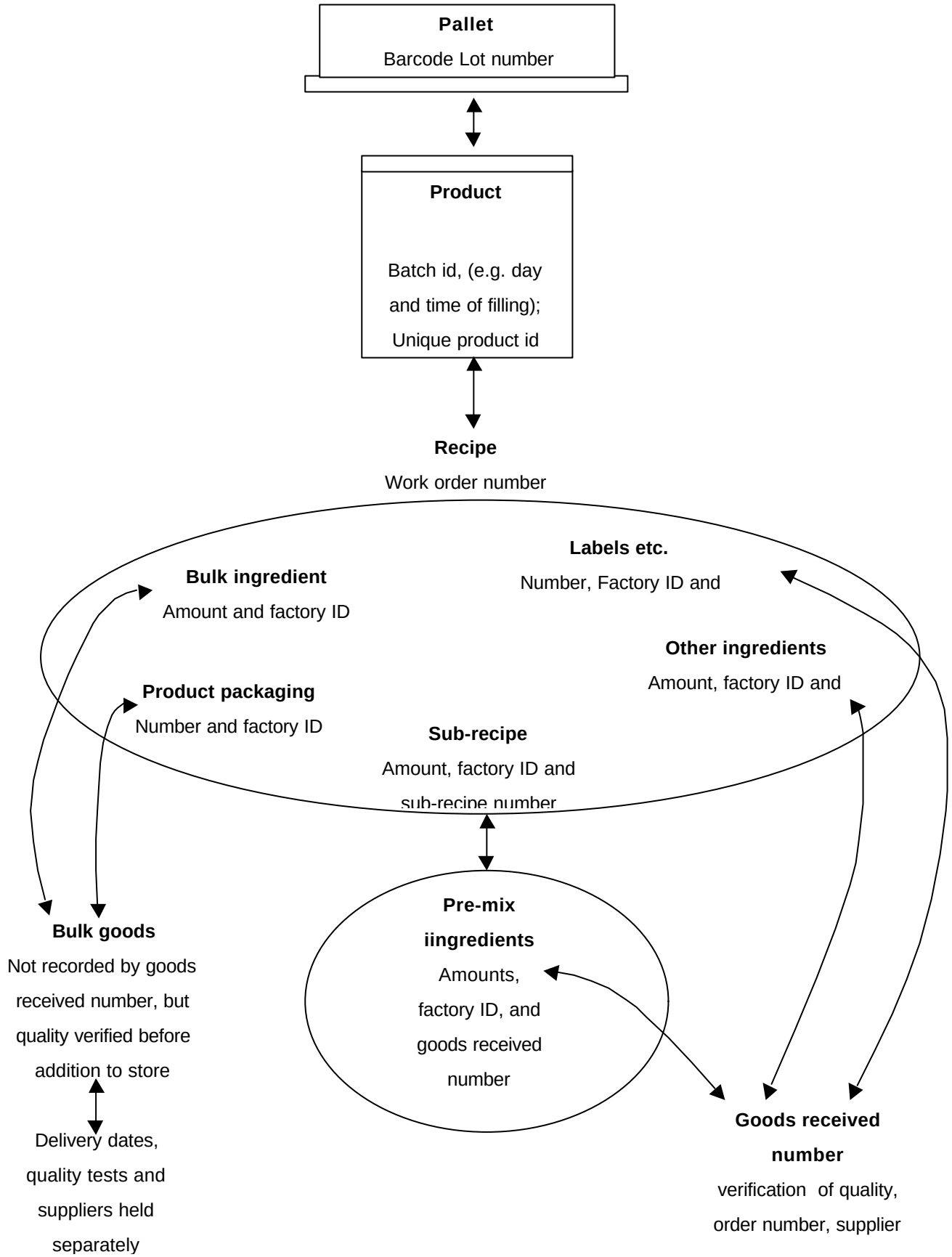
84. There is a range of systems for traceability in use across the industry. However, their basic characteristics are the same, whether the systems are IT enabled or paper-based. In large manufacturing businesses, full business systems underpinned by large computers or networks are becoming more common. However paper-based systems may be used to link the product identification and associated information even in the largest companies. *"Most important is that traceability is built into working practices and culture".*

85. Figure 3 illustrates the links between identification and information through a manufacturing process. On receipt goods are booked in, their specifications checked and they are given a lot number. From the store, raw materials will be booked out to the factory as they are needed and their use is linked to manufacture (by date and time of use, works order, recipe etc.). The final product is given a traceability/lot code (date code, time of manufacture, lot number), which allows production to be grouped and gives a link back to the raw materials used, time of the production run etc. For despatch, products may be grouped onto pallets, or into boxes, which may be given separate identification codes for use in despatch and subsequent handling in the supply chain.

86. While in overview traceability systems in food manufacturing are similar, their detailed implementation is different and closely related to process management. In continuous processes, manufacturing windows can be defined by a regular sampling pattern (for quality analysis) at some point in the process, where the time taken for the product to pass through the process identifies these windows further down the line. Date/time markers may also be placed regularly into a production line and their appearance at later stages in the process can be recorded and create

manufacturing windows. Even for continuous processes, batches are usually created for despatch – *e.g.* tanker, box, pallet of bags. Batch codes created at this point often record the date and time of packing and may also indicate the packing line or silo from which the product was loaded.

Figure 3 Schematic diagram showing linked information within a process traceability system from raw material receipt (at the bottom) to the finished product awaiting despatch (at the top).



87. The larger the window used for batching the simpler the system is to operate, but the larger the amount of product, which may require to be withdrawn. The size of the traceability windows for recall may be as wide as a day's or as narrow as 15 minutes production. The size of this window is a business decision based on what is practical in relation to process management and also on wider considerations relating to business risk management.

88. The detailed and complex information in traceability systems lends itself to recording, compiling, transfer and interrogation by electronic means and there is an increasing move towards making traceability systems IT enabled. IT enabled systems may also use data-scanning by incorporating bar codes or RFID identification systems which can be read automatically for raw materials or during the process. These inputs can speed up data recording for traceability and reduce errors in data entry. Some components of a fully automated system may be expensive; most systems are designed so that they can be implemented in a staged way. The cost of training may also be high in initial implementation phases, but it is critical that the system is understood and fits into the working pattern of the staff.

Between businesses – creating food chain traceability

89. Robust and effective systems/frameworks to provide "farm to fork" traceability of food are not present within the food industry at the moment, except in some very niche areas (*e.g.* beef and some retailer chains for meat and produce). The development of a framework protocol for the effective implementation of traceability of products throughout the food supply chain is the subject of a EU project – FoodTracE which began in January 2002. This is part of a loose cluster of projects also working on aspects of traceability implementation in the food chain – FOODTRAK and EID & DNA TRACING. The aim is to develop a protocol that extends the concepts of traceability from item tracking to include aspects associated with safety and quality.

90. The UK has been relatively slow to introduce all forms of Business to Business (B2B) software developments. Perceptions linger in the industry that B2B would give competitors access to confidential data, that competitive advantage might be lost or that somehow businesses would lose control of their operations. However,

companies that have been involved in B2B so far have discovered only advantages in speed and processing of information following careful implementation.

91. A food chain traceability system would be characterised by a backbone of connectivity between robust databases with lateral connections to national/local users. This would need to be held together by agreed standards for the elicitation, representation and storage of the required data. The system would not need to operate with constant connectivity. Data might be held locally either within the management system of a business or associated with the item itself, *e.g.* with barcodes or RFID as appropriate or in combination. When connectivity is achieved at a key point of the chain, the cache of information on the item could be updated.

92. In the simpler supply chains, *e.g.* meat and fresh produce, systems using this model have been developed. However, their development and operation has identified some major limitations and constraints due to a lack of trust between players; fragmented industry bodies; reluctance to take risk; consumer voice not focussed to demand improvement in some sectors; and, cost management considerations due to the high capital investment required. In addition, a large majority of companies involved in food chains are SMEs so simple tools need to be available for their use, so that their compliance is painless and low cost. Access to IT and internet may need to be facilitated. However, extra value can also be delivered to participants when creating connectivity. This may be as simple as facilitating a wider information exchange or enabling the establishment of other B2B frameworks.

Accreditation and verification of traceability systems

93. Traceability systems are critically reliant on the recording of information accurately through the food chain. There is therefore a great degree of trust and responsibility placed on every operator in the food chain. Any traceability system is only as good as its physical and data security measures since without such security it would be nearly impossible to prevent fraud.

94. In most audits, traceability systems are assessed through a challenge to the system by performance and speed. ‘Contaminated’ products, selected at random for a test, must be identified back through the production process and any products related

through a common process or ingredient batch identified for withdrawal quickly and effectively. It is critical to have such a programme of challenge to any traceability system occurring regularly and in all dimensions. The most stringent requirements noted by any customer was for full traceability back from a delivery to the customer to the supplier's raw material information in 2 hours.

95. Verification and assessment of traceability systems is therefore currently according to goals, rather than simply defining an ideal system, since the industry is too diverse for any blueprint approach to be successful. Traceability systems may be checked to see if they meet the following goals:
    - Provide traceability forwards and backwards
    - Establish clear manufacturing windows for continuous production
    - Be comprehensive and include all materials and ingredients
    - Give a response in an appropriate time (relate to risk and shelf-life)
    - Provide simple readable traceability information to the customer

    "If traceability becomes mandatory, then what is 'adequate' will need to be carefully defined by what it is economically possible for any part of the food chain to achieve. This may be decided by the turnover of the business or related to the type of production. It is unlikely that those involved in taking or producing bulk ingredients will be able to batch in the same way as producers of small discrete items."

96. Some retailers require traceability for produce and meat products back to an individual farm level. This information may not be held in one system but require the co-operation of several links in the chain. However, as such traceability systems are a requirement to be able to supply the retailer, they are put in place and maintained through regular auditing.

97. Paper records can be lost, spoiled or rewritten, while well-configured computer systems cannot. IT driven recording systems create unalterable data and time verified records, whether they were recorded remotely or by an operator keying in data. IT systems therefore reduce opportunity for information to be entered incorrectly or fraudulently (particularly where machine readable identification systems and remote sensing replace human data entry). Data entry can also be

linked to personnel since user identification is recorded against data entry. The level of system access can also be restricted by user identification. IT driven record systems also encourage the management of compliance to standards as a continuous process, since there cannot be a panic completion of all the missing records for the last year on the day before an audit or inspection. Electronic record keeping standards (21CFII) have been and continue to be improved to give electronic records veracity as reliable records in court (*e.g.* in relation to patent lodging from laboratory notebooks). It is likely that the security given by electronic record keeping will only continue to increase. "*In comparison to the security of current paper record systems the discussion of 21CFII is like offering people icing when they haven't even got cake. Simple date and time stamped unalterable*

However, any information stored will only be as good as the data entered, it is almost impossible to envisage/construct a system, which is completely invincible to fraud.

98. Where traceability systems are being used as conveyors for other product related information, it is important that systems can be verified in other ways. Analytical solutions may not always be possible, but in some cases the use of specific markers can be used to support and check traceability systems. Authenticity methods are already being applied to prevent mis-description of foods and protect the consumer from fraud. Sensitive methods are being developed using specific DNA sequences to check species, variety origin, or genetic modification of the food or any adulterants that might be added. Methods using other specific markers such as stable isotopic ratios and trace elements can be used to establish geographic or plant origin of foods/wine. *E.g.* Curie point pyrolysis mass spectrometry has been used to develop a fingerprinting method, which proved a useful discriminative tool for rapid identification of an oyster production area[4]. Some of these methods can be applied as one means of supporting/verifying traceability documentation *e.g.* DNA samples from animals taken at the slaughterhouse are maintained as a verifiable check for the origin (to farm level) of butchery cuts of meat by one retailer. For other

[4] Cardinal, M., Viallon, C., Thomat, C and Berdague, J. L. (2000) Pyrolyis mass spectrometry for rapid classification of oysters according to rearing area. *Analysis*, **28**, 825-829.

methods, further research is needed. The cost of such procedures means that they are not likely to be routinely used except for high value products.

99. The European Federation of Wine and Spirit Importers and Distributors (EFWSID) Voluntary Code of Practice for Traceability and Standards of Hygiene for Wine ties together detailed record keeping with a chain of samples taken and stored throughout the wine-making process. It is not yet clear how often these samples would be required and analysis would occur. However, it has been demonstrated through the implementation of a test emergency situation that such a system provides an essential verification system for the traceability recorded in a paper trail.

Interactions between traceability and other management systems

100. The specific requirements for the extent of traceability (*i.e.* how much information is carried) will vary and depend on the nature of the product, on farm practices or other agri-food chain operations, customer specifications and legal or codes of practice requirements.

101. Many applications of traceability systems with the food chain at present seek to enable finished product to be identified within a defined assured supply chain. Within this context, product and process traceability is seen as part of a quality assurance management system, in the same way as was highlighted for the traceability of analytical measurements at the beginning of the report.

102. Within food manufacturing it is common to see traceability systems used alongside HACCP to provide verifiable documentation which monitors the critical control points and allows remedial action to be taken if product falls below quality. Some manufacturers consider their traceability systems (dominantly linked to process control) to be separate to HACCP (linked to quality management). But others consider traceability and HACPP to be irretrievably intertwined as part of a product quality management system. These may not necessarily be opposing views, but represent different viewpoints related to how the systems have been implemented in practice.

Traceability systems in various sectors

Animal identification and tracing

103. Animal identification has been practised over centuries to prove ownership or to maintain breeding programmes. Systems of ear punch marks, horn brands and tattoos are still in use, as are freeze bands, collars and colour marks for management identification purposes on farms. New Zealand and Switzerland are world leaders in the tracking of animals with the link between individual animal identification and a spatial GIS database of holdings resulting in a spatial as well as informational trace of an animal from birth to slaughterhouse. Such a database gives valuable extra information in the tracking and understanding of occurrence of animal disease.

104. The British Cattle Movement Service runs the mandatory cattle identification and registration scheme, which operates from birth to death of each individual animal. The four elements of the cattle identification and registration scheme are as follows:

Tagging: Cattle must have a unique number, which are issued at birth and recorded on two eartags per animal, one in each ear (to reduce risk of lost identification);

Farm records: records of cattle births, imports, movements and deaths must be kept by farmers;

Passports: cattle born since 1 July 1996 must have passports. This passport accompanies the calf throughout its life, recording where they have been. Older cattle have been issued with certificates of CTS Registration;

The Cattle Tracing System (CTS): the CTS is a computer based system to register cattle in Great Britain. The CTS records the identification and death of cattle, the movements from birth to death of cattle issued with passports from 28 September 1998, and the movements of older cattle since 29 January 2001. Records of cattle movements are therefore made in the farm movement book, on the central database and in the passport. On death the passport is returned to the BCMS.

105. Barcodes are used on the cattle passports to avoid transcription errors. Cattle keepers can now register new calves and check information held on their cattle on

the CTS online. There are a number of commercial companies offering services to farmers whereby cattle records including full management and veterinary information are maintained on databases held externally to the farm gate which are updated either through web links, telephone contact or email.

106. While the BCMS has markedly improved cattle traceability, there are still a minority of cases where the rules are not followed to the detriment of animal welfare and traceability.

107. Under current EU rules sheep and goats are marked to identify the premises of birth. However, this system does not facilitate the tracing of any intermediate holdings where a particular sheep or goat has been kept between the holding of birth and slaughter. In much of the pig and poultry industry, strong vertical integration of holdings occurs within the same or allied companies, individual identification may therefore be less necessary. The UK National Scrapie Programme intends using RFID to support its genotyping programme. This scheme is voluntary but animals involved in it will be tagged. Individual tagging for sheep and pigs has also been proposed in Northern Ireland.

108. There is widespread agreement that electronic identification (EID) and electronic data transfer (EDT) are the best way forward in the medium-term for delivering individual animal identification and traceability, in line with delivering EU plans. RFID may be attached to or form part of the eartag, be implanted subcutaneously or be incorporated in a bolus placed in the reticulum of ruminants. The preference seems to be towards devices, which can be implanted in the animal or given as a bolus.Work has already been done on EID and EDT (including on-line access to the Cattle Tracing System) and this indicates that no one system fully meets the requirements and that some technical development is still required. There is a trial project in place to test electronic identification systems in practical farming situations within the EU called IDEA (Identification Electronique des Animaux) which reported to the EU Commission at the end of 2001. It is most likely to be 2005 before EID/EDT is fully operative.

109. There is an increased willingness in the industry (National Sheep Association, National Farmers Union) in the light of FMD to introduce EID across a wider range

of livestock species early to enable better tracing of livestock movements and to increase consumer confidence. Concerns from farmers and associated groups (British Veterinary Association, National Pig Association, National Sheep Association) reported in Farmers Weekly (4/5/2001) are mainly related to the cost, practical difficulties and welfare implications of the introduction of such a scheme. Initial broad-brush estimates for introducing EID/EDT for sheep are of the order of £100 million for implementation with ongoing annual overheads of the order of £20 million. However, the MLC has estimated that cost-savings through being able to track down disease more quickly would outweigh the cost of introducing such systems. (Farmers Weekly 4/5/2001)

110. The cost of implementation of human security technology, such as DNA profiling, currently outweighs its potential in this area. However, such technologies are likely to continue to be used in high value sectors.

Beef Labelling Scheme

111. The Beef Labelling Scheme completes the traceability chain from abattoir to plate for fresh and frozen beef/veal, but not processed beef products such as steak and kidney pies or processed beefburgers. All businesses which sell fresh/frozen beef/veal at any point in the supply chain must have a traceability system in place linking the animals or beef that is bought into the system to the beef that is sold.

112. From the 1st September 2000, a label had to be provided either on or clearly associated with the beef that was sold detailing:

Reference number/code;

Slaughtered in (name of Member State or third country);

License number of slaughterhouse;

Cut in (name of Member State or third country);

License number of cutting plant (s).

From January 2002 additional information giving details of the Member State(s) or third country where the animals were born and raised is also required. The label British beef can then be used of meat where all the sectors of the chain are within the UK.

113. Any other labelling, *e.g.* showing breed or specific details of farming systems, continues to be subject to approval and verification by the appropriate authority.

114. The key concern of the Beef Labelling Scheme was that consumers would be able to see that labelling on beef afforded them some possibility of being able to trace the beef back to the point of origin. In this regard the EU commission was sceptical of barcodes or abbreviations, which would be unclear to consumers, even if they still enabled full traceability to be demonstrated and enforced by competent authorities.

115. There are some genuine but fairly minor difficulties in the implementation of this system, especially where meat is displayed non-prepacked. However, these difficulties should not be allowed to discredit the scheme as a whole. It may be interesting to compare the activities of the accredited third party verifiers demanded in the voluntary scheme with the enforcement of the mandatory scheme by Trading Standards Officers. Enforcement control of mandatory traceability (for which the BCMS and BLS provides a case study) depends not only on officers being provided with adequate training to develop the necessary skills but also on the relative prioritisation of the workload of enforcement officers.

Use of DNA tracing for beef products

116. This development takes traceability on from the abattoir to the butchery counter and links into the life history of the beef animal, which is tracked from the abattoir back to the registration of its birth by the BCMS.

117. Beef animals are slaughtered in 50 animal batches. During handling at the abattoir, blood spots from each animal are absorbed on a special paper which 'stores' the DNA. The development of this methodology, which is able to lyse cells walls and preserve DNA and RNA for more than 10 years at room temperature, is critical to the development of this system for routine use. The samples are stored at the abattoir for at least the 50 day cycle that fresh meat from that batch of animals is available in the stores.

118. If full traceability is required for any meat cut, the batch of animals from which that meat originated can be rapidly identified using normal traceability records. A sample of meat is sent away and a 'card' taken for DNA analysis. The stored

relevant batch of blood ‘cards’ is also analysed. The meat cut can then be identified to a single animal (or one of a pair of identical twins, occurs only very rarely in cattle breeding) using multi-focus STR, a DNA comparison system akin to that used in the Forensic Service for human identification. The number of analyses necessary are limited through the batch system at the abattoir.

119. This system is currently only used in the fresh meat sales area of the retail operation. However, it is equally feasible for meat products, though it would need verification. Equally the system would operate equally well from the birth of animals rather than from the abattoir, so a sample could be taken and held from birth, which might be collected at the same time as ear tagging occurs.

Farm Assurance Schemes

120. Farm assurance schemes have developed as a result of both push and pull drivers throughout the food chain, as farmers seek to create added value for their products and consumers demand higher standards of environmental protection, animal welfare and food quality. Farmers and industry bodies have developed these schemes to define standards in excess of the legal minimum required within which production must be carried out, which usually encapsulate best practice within the industry sector or even more stringent requirements *e.g.* RSPCA’s Freedom Food. Many of the assurance schemes are accredited with UKAS and have a framework for independent accredited assessment of the schemes to EN45011 or the international equivalent ISO65. Other schemes are currently working to this goal.

121. Assurance schemes each operate only within a limited part of the supply chain, but all seek to ensure traceability within that sector and also create links both upwards and downwards with other parts of the food chain. There are increasing moves for co-recognition between assurance schemes. In some cases this has required a careful examination and changes in the requirements at the edges of the scheme *e.g.* a change in the standards of the National Dairy Farm Assured Scheme (NDFAS) so that calves produced could be accepted by the Scottish Quality Beef and Lamb (SQBL) Scheme. Concern has arisen amongst some of the smaller independent schemes about the degree of access that they have to this chain, as it

may be difficult to demonstrate equivalence. The maintenance of fair competition in this area is critical to maintain consumer choice.

122. The key definition of traceability within assurance schemes is the tracking and maintenance of a product within an assured chain to ensure that a particular logo can be used for marketing. Segregation and identity preservation of assured products within the larger food chain is also critical. Farm assurance schemes are currently in various stages of development and consequently the standards set within each scheme for traceability are different. Some have detailed and prescriptive demands for traceability, others not, partly dependent on the sector in which they operate. Even the more prescriptive schemes set goal-based requirements. Schemes may demand a demonstrably effective traceability system and may prescribe that it is tested regularly. However, in no scheme are the mechanisms for developing a traceability system specified, except in the case of the mandatory schemes in relation to cattle.

123. Organic production systems can be considered as a legally enforceable farm assurance scheme, which operates throughout the food chain. Within organic regulations, the focus has been verification of processes and maintenance of product integrity through the food chain. This is achieved through the certification of registered premises for production and processing of organic products.

124. However, recent amendments to the regulations have included traceability requirements especially for the processing side. Guidelines provided by the organic certification bodies reflect those required of all food manufacturers under schemes such as BRC, with additional requirements in relation to contamination with non-organic ingredients. Processors and importers are required to maintain precise up-to-date documentation, which establishes control of the process and permits traceability. These records must be sufficiently comprehensive to allow organic raw materials used in finished products to be traced back to their original source. These records must be retained for a period of not less than 3 years.

125. Although specific traceability is not required at the farm level records are required to be kept of:

the quantity of seeds and transplants brought in and their origin

any bought in fertilising materials or manures

management inputs on a crop basis

any pesticide applications

manure exchanges with other holdings

livestock purchases and sales

crop sales with amount and destination

veterinary products purchased and their use on an animal basis

livestock feeds and feeding regime for each animal.

These records can give some degree of traceability within the system.

126. Computer systems have been developed specifically for the organic industry, which enable the maintenance of up-to-date farm records and link these to create traceability throughout the food chain. These systems are currently only available for crop products. Organic certification bodies have worked with companies developing such systems, so that they can be used for distant pre-audit. Where such systems are in place on a farm then a reduction in cost of certification can be obtained.

Food manufacturing

Supplier assurance

127. Food manufacturers are commonly audited by their customers, particularly if they are supplying into the supply chain of a large retailer. Food manufacturers have therefore widely adopted supplier assurance with regard to the specifications of the raw material, and perhaps the processes that have been used in its production. Audits include challenges to the traceability system of the suppliers. An effective traceability system is judged to be a critical requirement for the approval of suppliers.

128. The selection of suppliers for any business is now driven by a close working relationship between the commercial and technical sections of the food manufacturer, so that technical and quality specifications are considered alongside price. In most systems, every supplier is carefully audited before first use, following the submission of a self-assessment by the supplier themselves. Suppliers are re-audited regularly with the regularity of visits set according to:

the product and the risks associated with it, the size of orders regularly placed, customer complaints which have been related back to raw material, and, to assess the response made to any requested changes at an earlier audit visit.

129. Raw materials that are judged to be business critical, either due to the high volume of their use or any food safety risk associated with it, may be audited at source, as well as through the intermediate supplier. Traceability systems have been used in many food chains to identify the origin/source of ingredients allowing supplier relationships to be managed directly rather than just dealing with the "middle men".

130. Supplier assurance is used as a tool to create an assured supply chain to minimise the risk of a food quality/safety incident. Within this chain, traceability systems provide a key line of defence when a crisis occurs.

Internal traceability in food manufacturing

131. Historically process and quality control systems were operated separately in food manufacturing. However, integration is now common and indeed the whole manufacturing process from recruitment of staff, through manufacturing to marketing of products is now increasingly handled as a single integrated process. The development of traceability systems in part reflects this change.

132. Paper–based systems are still widely used for traceability systems in both large and small companies, and even within systems operating across the whole food chain. Guidelines for the introduction of paper-based traceability systems and an introduction to food safety issues for SMEs have been prepared by Plymouth College of Further Education with funding from the European Social Fund. Manual entry of data to databases through the production process or at regular intervals from hand-written records is also common. Often these databases are linked to other current software packages *e.g.* accounts management systems or stock handling and reconciliation systems.

133. Enterprise Resource Planning Systems (ERP) [and bigger e-collaboration systems] are large business management systems which operate at all levels within a company: inventory management, operation planning, sales planning,

maintenance, document control, quality control, human resource management, salaries and much more. Investment in such systems has been a major commitment within all sectors of manufacturing in the last decade. Different suppliers operate to deliver ERP systems to customers of various sizes, so that company size is not a limiting factor for the introduction of an ERP system.

134. Where installed the ERP system is the main driver throughout the factory for ordering of goods, manufacturing planning and financial systems. The system is accessed on networked terminals throughout the company. Different users are given varied levels of access according to their password. Data entry can be cross-referenced using internal checks so that errors are difficult, while not absolutely impossible. At any point following receipt of goods their position in the system is indicated by ERP system. Traceability is inherent within the system and necessary for much of the functionality *e.g.* measuring the efficiency of process management. However, it is rarely one of the main goals. The ERP system provides a one-stop shop for information, which can be very quick in case of emergency. It may take only minutes to identify all related batches through their ingredients etc. The development of ERP systems to deliver both forwards and backwards traceability as a key outcome is on-going.

135. Companies supplying industrial automation equipment are also increasingly demonstrating how it can be used as part of an integrated system of products, technologies and support services to deliver traceability. Data collection throughout the production process is becoming more common and more automated. Machine readable identification systems can allow in process traceability to be demonstrated. Programmable logic controllers can be used to establish communication between separate process elements throughout the plant. This information can be managed and interpreted to deliver critical data relating to the process control points, as well as data which can be used to derive yields and process efficiency information.

136. Specific food safety/quality management systems have been developed, these include laboratory information systems. Some systems act as approval systems for raw materials. Where details of suppliers and emergency contacts can be stored on

this database, some backwards traceability can be delivered. Other systems are used to handle recipe formulation and raw material information for complex products and compile information on individual product specifications. This is coupled with information obtained through the manufacturing process to create the product reports required for each customer. IT based systems have been introduced in this area to give greater accuracy and control of information while reducing transcription errors and reducing the time taken by 90% compared to paper-based systems.

137. It is clear that different systems relating to traceability in the manufacturing process have been introduced at different times for different reasons. This may create data islands within the company, where data is held on separate computer systems or in different filing cabinets in separate offices. For most efficient operation of traceability systems, rapid access to all data from the production process from raw materials purchase to product distribution presented in a seamless and cross-referenced manner is essential.

138. There are now IT–based systems, which have been developed with the specific aim of fully integrating information from other management systems (ERP, specialist process control and laboratory information management systems) at a range of scales. These integrating systems seek to deliver control in the management of quality throughout the manufacturing process by linking up and integrating data collection and recording systems throughout the plant/operation giving real-time validation to ensure compliance with quality procedures and guaranteeing full backward and forward traceability. Such systems may give greater control throughout the manufacturing process. Goods can be held until conformance tests are passed and products can be directly supplied to the different specifications of a range of customers.

139. Many of the difficulties in the implementation of traceability systems within manufacturing systems are related to determining the traceable product unit size (what size should the batch be?), which is determined by the details of the particular process management. Some of the key areas of difficulty identified were:

Continuous and batch processing and the transfers between such processes within the manufacturing system.

The handling of **bulk products** (sugar, salt, glucose syrup, flour).Even where goods are delivered with clear batch identification in a tanker, they may be emptied into a single silo and mixed with earlier deliveries, so onward traceability may not be maintained. Silos also have dead zones in filling and emptying, which can cause the blending of successive batches. Changes in handling practices can increase traceability and telemetering can be used to carry forward any batch identification system provided a delivery into the process.

Rework of any component of the recipe expands the traceable unit, so that whatever other traceability systems are in place, the size of traceable unit is actually all the product produced between two breaks in the rework cycle. Just because any rework is traceable, does not mean that the contaminant is not dispersed through several days/months/years or production. Any rework cycle can have significant implications for product recall

Water used in food processing and manufacture. Are records of date and time of manufacture good enough?

140. Really detailed application of traceability systems is always possible, but such an implementation in any business could be very high cost and of little benefit for consumer safety, if the next step in the chain does not maintain or improve on the size of the traceable unit. Risk assessment is the key step in the design of a traceability system which enables the management of risk, dependent on the raw material purchased and the final product that is produced. Tracing absolutely everything to the nth degree may be an unnecessary safeguard.

141. Companies currently investing in integrated quality management systems, which integrate information and deliver rapid, validated traceability are more likely to be :

- seeking to use product quality as a differentiating criteria in the market place
- seeking to manage/reduce risks to shareholders and have recognised quality as a major factor
- seeking to reduce the impact of product recalls on business by reducing recall widths and minimising the need for recalls from customers
- working in complex industries where the provisional of batch specific quality information is critical to ensuring a market (shell fish based on safe harvest zones

defined by regular Local Authority analysis)

- working to achieve/maintain an ISO9000 standard within the company
- seeking to reduce the impact of preparation for and audit visits from suppliers by always being ready
- seeking benefits in improving yields and performance in the process by reducing waste and constantly improving process quality

"*They won't buy the system unless they are really committed to quality*"

Foodservice supply chain

142. Foodservice operators, who serve food to consumers and public institutions, have not had the same dominance in their supply chain as the major retailers have in theirs. Within the sector, there is a huge diversity of outlets ranging from large multi-national chains with franchised outlets to small street corner kebab and fish and chip shops. There are at least 300,000 foodservice outlets. Manufacturers of products often also supply the retail sector. Goods are transported by 3 major distributors;some regional and local distributors also operate. Wholesalers represent a key narrow point in the Foodservice sector and are represented by trade bodies. However, 30% of sales to caterers occur through the cash and carry and $^{2}/_{3}$ of foodservice outlets are supplied by independent wholesalers.

143. There are moves within the Foodservice supply chain (through OFSCI, a FDF and FWD sponsored project) to increase supply chain efficiency by adopting new technology. The main driver for such a project is the potential cost savings available to business in improving efficiency. There has not been a sufficient degree of trust developed in the past both horizontally and vertically within the Foodservice supply chain for B2B initiatives to operate effectively. Through this project, the extended bar code (EAN 128) is being introduced as standard for Foodservice packaging by manufacturers. This code can carry more product information and may indeed link product to batch, and is readily machine-readable.

144. Currently traceability in wholesale distribution means knowing where the products have come from and to whom you've sold product. You will have good records of the quantity of each product type, but it is less likely that you will have records on a batch

or lot code basis. Lot numbers of product are likely to be recorded when received goods are checked in to the depot, as well as checking product quantities etc. to the specifications in the order. The products are then transferred to a picking location where the stock and picking rotations ensure that the oldest products are sent out first ensuring the longest shelf-life to the customer. However, picking is not currently done by batch code. Therefore it is known what is sent to the customer (product and quantity and when it was sent) but not the batch codes sent. Picking by batch code or at least the recording of batch codes picked for a particular delivery would be possible but time-consuming. It is likely to only be a realistic possibility when the system is automated using barcodes or other tags to facilitate the collection of information.

145. Where traceability is called in to play in the reverse situation, *i.e.* in response to a customer complaint, the quality of information that can be provided up the chain at that point is critical. Much of traceability is lost once the food has been served. The menu item that is the direct cause of the complaint needs to be identified as quickly as possible. However, it is extremely rare (if ever done) for the usage of ingredients into individual dishes to be recorded by batch code or even the batch codes of pre-prepared meals to be recorded by time of use etc. It may be possible to go and look in the store. However, it is common for goods to be debagged or decanted on delivery. Codes are often only printed on outers and so they may be lost in this process. A method is needed to help caterers maintain good retrospective information in case of a recall. It has been suggested from within the industry that a duplicate label is placed in the product outer box and retained by the caterer. Caterers could organise stores to facilitate traceability and keep this information. However, to date there has not been a requirement for caterers to record this information and this may be a difficult area in which to implement traceability. The understanding of the caterer (consequent on training) is critical for traceability to be carried to as close to the fork as possible.

146. Consumers (and intermediate consumers such as schools) often challenge the origin or ingredients of products supplied. (*e.g.* with regard to allergenicity). Currently verification is a painful and long-winded paper and telephone chase. The

information required in this case is mostly static information with regard to product make up and origin of ingredients. It does not need to be provided on a batch by batch basis. The transfer of information from manufacturer to distributor to customer is a very big challenge in this sector.

147. It is critical that the right mechanisms are put in place:

1) to facilitate the collection and authentication of the information from manufacturers, importers and processors;

2) to enable the information to be shared through the chain;

3) to keep the information up to date.

The OFSCI project is striving to develop a product database for the Foodservice industry which will act as a record of product information and which can readily accessed and searched. The information will be entered by manufacturers and include records with information needed for logistics planning as well as ingredients etc. While this information is static, it still needs to be updated regularly to reflect changes in formulation or processes. So the relevance of the information relies on the flow and accuracy of data from manufacturers.

Specific areas of concern

Food brokers

148. The brokerage of food and feed is recognised as a possible problem area with regard to providing increased opportunity for fraud and as possible breaks in a traceability system.

149. Until recently many food ingredients have been routinely handled as commodity goods with frequent sub-selection of products and mixing of batches *e.g.* fresh produce in the wholesale trade, some low value meat and meat products.

150. Many companies operating with the retail chain have already introduced codes of practice for agents and importers. The agent is required to demonstrate full knowledge of the supplier and the company reserves the right to inspect and audit the competence and traceability system of both the agent and their supply chain back to primary producers. Similar requirements at other points in the food chain and increasing numbers of traceability audits would reduce the opportunity for

fraudulent practice through brokers. However, no system can ever prevent deliberate fraud.

Handling incidents and alerts

151. Much of the industry noted that the handling of Hazard warning notices and the quality of the information provided has improved markedly in the lifetime of the FSA. However, during the handling of hazard warning incidents, more information should be provided for the perspective of the catering industry *i.e.* Is the product, if already used as an ingredient safe to consume? If you have just incorporated the product as an ingredient into a dish, does this also need to be recalled?

152. The cost of recall can be significant *e.g.* the corporate recall by Coca-Cola in 1998 cost the company $66 million directly, with indirect costs in addition. "*The poor handling of a serious incident within a company can cause irreparable damage to the company, to the brand or even the industry, and certainly to the reputation of those in key positions*".

153. Within the industry, traceability is recognised as a key system with regard to incidents and alerts. While traceability can seek to monitor systems in place to minimise the risk of problems, it also equips you to deal with any incident. The role of traceability systems is to deliver intelligence in emergency situations. This enables the facts to be gathered and the scope and scale of impact to be determined rapidly.

International trade

154. Under the EU General Food Law Regulation, importers and exporters of bulk goods will not need to be able to demonstrate traceability back to the primary producer. Traceability can only be required from the EU border, so that only the direct supplier to an importer, based in the EU, would need to be identified by law. The current market position is to obtain a contract agreement, which identifies both the buyer and seller, and for acceptance of goods to be dependent on analysis of quality at the point of delivery. This level of traceability would satisfy the requirements in the EU General Food Law Regulation.

155. Suppliers dealing in retail chains are already required to demonstrate traceability, if requested, back to the level of an individual farmer, even one outside the EU. This vertical integration in the international trade in fresh horticultural products has been demonstrated by Barrett et al[5]. While the supermarkets have no direct investment in Kenya, they control production there through intermediaries who ensure that standards of quality and presentation are met. Importers play a critical role in acting as a link between farmers and exporters in Kenya and supermarkets in the UK. The need for quality and traceability dictates that contractual arrangements are usually made with large scale farms using industrial farming methods.

Costs of implementation of traceability systems

156. Not everyone within food chains sees better information as a value added to the product and many steps rely on a physical inspection of quality. Most steps ($^{7}/_{8}$) in the fish distribution chains interviewed by Frederiksen and Bremner[6] said it would be an advantage to have increased internal traceability. However, one small producer disagreed since it would be no advantage for them "only more paperwork".

157. The cost of implementation of traceability systems is likely to vary enormously between business and sectors depending on the type of technology adopted, the amount of information required to be stored and the complexity of the food chain. It is most likely that systems will be introduced most rapidly where commensurate benefits in logistics, process control *etc* also occur for the business, or where market share would be jeopardised without the introduction of such systems.

158. The highest costs will be borne by businesses, which still operate to a philosophy of commodity production, and the lowest costs to businesses, which already operate with their focus on the production of high quality products and the creation of added value by brand to meet customer demands. (These business types represent a

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[5] Barrett H. R., Ilbery, B.W., Browne, A. W. and Binns, T. (1999) Globalisation and the changing networks of food supply: the importation of fresh horticultural produce from Kenya into the UK. Transactions of the Institute of British Geographers, **24** 159-174

[6] Frederiksen M. and Bremner A (2001) Fresh fish distribution chains. An analysis of three Danish and three Australian chains. *Food Australia*, **54**, 117-123

simple representation of a chain of producers with a range of motivations. Obviously the actual situation will be more complex and other factors such as the type of production/supply chain, location, and customer base will have major impacts).

159. It is clear that traceability comes at a cost. But the costs of not having it, or having inefficient systems in place may be severe both for governments, consumers, individual companies and the food industry as a whole

Food Chain Strategy Division, September 2001