4.1 Quality and Safety in Food Supply Chains

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1 Introduction

The modern consumer demands food products of high and consistent quality, in broad assortments throughout the year and for competitive prices. Consumers have also become increasingly concerned about the quality and safety of food and the negative effects of bio-industrial production, which has been strengthened by several sector-wide crises in the last decade (such as the BSE crisis, the dioxin crisis and classical swine fever in Europe).

> *After the discovery of BSE in cattle as the probable cause of the in humans deadly variant Creutzveldt-Jacob, there has been a large-scale crisis in the European cattle sector. Between 1990 and 1999 there was a reduction in sales of cattle meat in the EU of 6% (with peaks and falls). The British meat sector suffered the most from the crisis in this period. In 2000 several new discoveries of BSE were made in other European countries, like France and Germany. By mid-February 2001, the consumption of cattle meat had dropped by as much as 80% in several parts of Germany.*

Together with technological developments and increased international competition, these demands have changed the production, trade, and distribution of food products beyond recognition. Demand is no longer confined to local or regional supply. The food industry is becoming an interconnected system with a large variety of complex relationships. This has spurred an enormous growth of product assortment in the supermarkets. Governments, both national and international, are responding to this by imposing new legislation and regulations to ensure safe and animal friendly production, restricted pollution and to economize on the use of resources. Examples are the Codex Alimentarius standards (FAO/WHO) and the EU-BSE regulations.

For food businesses this implies placing more emphasis on quality and safety control and environmental issues, while at the same time shifting from bulk production towards production of specialities with high added value. To comply with the new demands, companies are also forced to introduce sophisticated information systems that focus on identification and registration and tracking and tracing capabilities. Furthermore, because of their

embeddedness in the network economy, collaboration with other parties becomes important for all businesses to achieve safe and high quality food products for the consumer. These processes are affecting the entire food chain from producer through to retailer (see also Omta et al., 2001).

In this chapter legislation and regulations on quality and safety, quality assurance systems, and tracking and tracing in the global food supply chain will be discussed. The next section describes regulations and legislation regarding quality and safety of food. Section 3 will go into quality assurance systems. Section 4 will deal with the contents of traceability systems. Section 5 will formulate themes for discussion.

2 Legislation and regulations on food quality and safety

2.1 Introduction

The purpose of food quality and safety legislation is to protect human health, to minimize environmental implications and to achieve fair competition by establishing uniform standards.

There are various legislative systems that act on different levels (Luning et al., 2002):
- Worldwide, i.e. Codex Alimentarius (FAO, WHO);
- European level, i.e. European food legislation;
- National level, i.e. Food and Commodity Act of the Netherlands;
- Branch level, i.e. regulations drawn up by commodity boards for e.g. dairy products.

In the following we will focus on the global and European level.

2.2 Codex Alimentarius

On a global level in particular the Food and Agricultural Organisation (FAO), the World Health Organisation (WHO), both UN-organisations, and the World Trade Organisation (WTO) deal with food safety issues. In 1962, as a result of the Food Standards Programme, the Codex Alimentarius was established by the FAO and WHO to act as an umbrella organization for policy making regarding food. The aim of the Codex is to protect public health and to support balanced trade relationships in food. For this purpose standards are designed and implemented. Codex Alimentarius food standard issues range from specific raw and processed material characteristics to food hygiene, pesticides residues, contaminants and labelling, to analysis and sampling methods (Luning et al., 2002). The Codex currently counts 165 member countries, representing 98% of the world population. Since the establishment of the WTO in 1995 Codex-standards are used in trade disputes. In this regard the WTO Sanitary and PhytoSanitary (SPS) agreement

plays a key role. It states that where a WTO member considers that a higher level of sanitary protection than afforded by Codex is necessary, it will have to produce scientific evidence based on valid risk assessment techniques. It thereby aims to prevent unjustified restrictions on international trade.

2.3 EU legislation

The most commonly used instrument for EU harmonization is a directive. This is a measure addressed to the Member states, which must be incorporated in the national regulation within a set time-schedule.

Three interesting areas of EU legislation on quality and safety concern labeling of food products, legislation with regard to hygienic and safety measurements and legislation on product liability in the food chain.

In the last decade there has been extensive new legislation regarding labeling of products (Anonymous 2001a). The aim of labeling is to inform the consumer about characteristics such as composition and origin. Table 1 depicts typical information provided on food product labels, as requested by EU legislation.

Table 1   Information on product labels

Name and type of product	Special instructions for storage or use
List of ingredients	Name and address of producer or packer
Amounts of most important ingredients	Place of origin
Net weight or volume	Instructions for use
Best-before date	Percentage of alcohol

Legislation regarding hygienic measurements and product safety focuses primarily on the required organizational measures needed to guarantee food safety. Food safety systems now generally refer to Hazard Analysis of Critical Control Points (HACCP) or related systems (see section 3). HACCP aims for identification, evaluation and control of significant and potential dangers related to food safety. HACCP systems identify a number of critical control points in business processes for which critical values must be defined. Measurement in these control points must lead to prevention of problems. Application of the HACCP concept is obligatory for most links in the food chain. An exception is the primary sector (the farm), where the HACCP concept is still in development. A next step will be the supply chain wide implementation of HACCP. To achieve this EU government aims to extend HACCP legislation to the primary producer, will design stricter rules for traceability, and will support development of supply chain wide systems.

The starting point of legislation with regard to product liability is that the legal entity that puts a product on the market, is liable for all damages caused by deficiencies of that product. So, a manufacturing company is always liable for the products it puts on the market, even if the company is not at fault. It is possible, however, to 'pass the buck' to other actors in the supply chain if a manufacturer is able to prove that the necessary procedures were carried out according to the dictated standards (e.g. HACCP). Other links that can be held responsible are the EU importer, the legal unit responsible for the product's brand name, or the legal unit that trades the product under a generic brand name (Commission of the European Union, 1999).

EU food legislation has a considerable impact on international trade and on daily business. An example is the discussion on Genetically Modified Organisms (GMOs) in food products.

In the last years a discussion on the labelling of GMOs (Genetically Modified Organisms) has arisen between the EU and the USA. Labelling of GMOs is obligatory in the USA only if the product differs essentially from the 'original'; if the nutritional value differs; or if the product contains an allergen that is not present in the original. The EU requests that all GMO products, with a GMO contamination of ≥ 1%, should be labelled as such. Another point of interest is that labelling requirements and retailers' action for products produced from, or containing, GMO's have, so far, been mostly limited to food products intended for human consumption. However, if the EU were to pass the EC's proposed legislative measures that extend labelling requirements to animal feed ingredients, the impact on countries exporting to the EU, notably the USA, could be very substantial. Retailers could require poultry and livestock producers to raise animals on non-GM diets. Since the EU greatly relies on animal feed ingredients imported from the USA (particularly soybean and MGF, a by-product of ethanol production), and if the USA is to continue supplying the EU, methods that allow the delivery of non-GM products will have to be developed. A considerable increase in the demand for non-GM products (at 1% contamination threshold) might lead to a substantial disruption of the market. So far, the USA market for animal feed seems to be suited to the delivery of bulk, undifferentiated products, but it could hardly respond to a more significant demand for non-GM products (Coppola, 2002).

2.4 EU General Food Law

A framework, and steppingstone, for future legislation on food safety is the General Food Law that was recently adopted by the council of ministers of the EU. It aims to offer a high protection level to the European consumer and supports free trade between EU countries. Furthermore, it should lead to harmonisation of legislation within the EU by defining basic conditions and constraints for food legislation (Food Standards Agency, 2002).

The General Food Law applies to the whole food chain, including agri-products and animal feed. It includes the following principles:
- food legislation should be based on scientific risk assessment, that must be independent, objective and transparent;
- the precautionary principle allows for temporary measurements for the protection of public health as long as science cannot give conclusive judgements;
- government has an information duty to its citizens if unsafe food products circulate in trade.

The precautionary principle applies amongst others to GM products. The General Food Law further states the primary liability of food (and animal feed) companies in the event of unsafe products. This implies the implementation of monitoring systems at company level. EU member states are obliged to monitor this (monitoring) process. With regard to traceability companies must in the near future start with registration of raw materials and customers on a transaction basis, to be implemented as of 1 January 2005.

3 Quality assurance systems in food supply chains

3.1 Introduction

As a result of consumer demands and new legislation companies around the world are increasingly implementing quality assurance systems to improve their product and production processes and to protect themselves against liability charges. This section will describe the major quality systems used in companies throughout Europe.

3.2 Company based quality systems

Common QA-systems in food production are Good Practices (e.g. Good Agricultural Practices (GAP) and Good Manufacturing Practices (GMP)), HACCP and International Standard Organization (ISO). GP and HACCP mainly focus on assurance by technological requirements, whereas ISO is more focused on management (Luning et al., 2002). I will discuss each of them briefly.

Good Practices involve guidelines that are aimed at assuring minimum acceptable standards and conditions for processing and storage of products. GAP and GMP are the most common GP codes. Some topics commonly included are personnel, buildings, equipment and utensils, manufacturing processes, storage and distribution. Depending on the comprehensiveness of the GP's, additional topics are included, like recovery of materials, documentation, complaint and recall procedures, labeling and/or infestation control (Luning et al., 2002).

HACCP is a systematic approach to the identification, evaluation and control of those steps in food manufacturing that are critical to product safety. HACCP identifies risks in the production processes that can lead to unsafe products, and designs measurements to reduce these risks to acceptable levels. It is an analytical tool that enables management to introduce and maintain a cost effective, ongoing food safety program. The basic objective of HACCP is assuring production of safe food products by prevention of hazards.

ISO standards are international standards in order to achieve uniformity and to prevent technical barriers to trade throughout the world. The essence of an ISO-based quality system is that all activities and handling must be established in procedures, which must be followed by ensuring a clear assignment of responsibilities and authority. Most used, and probably best known of all ISO standards, is the ISO 9000 series for quality (ISO, 2001).

Quality assurance systems enable the application and verification of control measures intended to assure the quality and safety of food. They are required at each step in the food production chain to ensure safe food and to show compliance with regulatory and customer requirements. Governments have an important role in providing policy guidance on the most appropriate quality assurance systems and verifying/auditing their implementation as a means of regulatory compliance (FAO, 2002). In line with this, there is a definite move from the old end-of-pipe product inspection approach to a new environment of a quality assurance approach where also the supplier assumes responsibility for safety. This means that food safety needs to be managed along the entire supply chain.

A recently developed, supply chain covering system, is Safe Quality Food (SQF). SQF aims at quality assurance in supply chains. Its bases are HACCP and the ISO 9000 series. SQF distinguishes between two norms. SQF 1000 focuses on primary producers; all other companies are certified according to SQF 2000. An important difference between both norms is that SQF 2000-companies must work according to HACCP. SQF has been developed in Australia and is internationally well accepted.

3.3 Retailer systems

Contrary to GP, HACCP and ISO retailer systems in general cover the whole chain, incorporating elements of company-based systems. Demands regarding food safety from (EU) retailers are best represented by two examples: Eurep-Gap demands and demands from the British Retail Consortium.

Eurep is an organization of more than twenty large European retailers (e.g. AHOLD, TESCO). Gap stands for Good Agricultural Practice; Eurep-Gap focuses on primary agricultural producers. It is a package of norms aiming to guarantee environment-friendly, safe and high-quality products.

Eurep-Gap pays major attention to food safety, human resource management (e.g. safety of work places) and environmental measurements (e.g. use of pesticides). The Eurep-Gap certificate is also developed to make business processes transparent. It makes tracing the origin of produce possible throughout the food supply chain. The demands are gradually increased (see www.eurep.org). The norms of the Eurep-Gap retailers are more rigid than (EU) governmental demands. A disadvantage of Eurep-Gap is that it takes the legislation of the country where it is implemented as a starting point. This explains why Eurep-Gap applications can differ from country to country.

In 1998 the British Retail Consortium, with participants such as TESCO and Sainsbury, has taken the initiative to define common criteria for the inspection of suppliers of food products. BRC focuses on food processing and distribution companies and it includes major aspects of HACCP. The inspections are carried out by certified inspection organisations. Before BRC was introduced retailers carried out inspections separately; joint inspections, however, reduce costs. Retailers in other European countries now also demand inspections according to BRC rules and accompanying quality reports from their suppliers. The norms of the British Retail Consortium regard hygiene and safety. For example, companies delivering to supermarket chain Albert Heijn in The Netherlands had to be certified according to these norms starting on 1 January 2002.

Within Europe we also find important differences in the demands of retailers. An example is the policy of British retailers to only buy bacon originating from pigs that have been raised in group housing. This demand is a translation of the wish of the British consumer to pay attention to animal welfare.

To arrive at harmonization of standards major retailers around the world have established the *Global Food Safety Initiative* (GFSI).

GFSI is an initiative of CIES, an organisation with large retailers as members. The CIES has installed a working group with quality managers of 44 retail chains with the aim to design a benchmark model to test food safety norms on a global scale. The aim is to use uniform norms and standards internationally, instead of the current way of working, with every country defining its own standards. GFSI underlines the importance of Early Warning Systems (www.ciesnet.com/ global_food/main.html). 'When a food safety issue arises, it is essential that information is made available and distributed quickly, accurately and clearly to all parties concerned. To address this need, an early warning system is being developed for the food industry, in close cooperation with suppliers. The objective is to provide a mechanism for the exchange of both general and crisis related information, in harmonisation with existing legal and governmental frameworks.'

4 Traceability in food supply chains

4.1 Introduction

As described before, traceability forms an important element in the quality and safety system of the supply chain. The basic idea of traceability is the possibility to determine where a certain item is located and to trace the history of that item. On the basis of that information, it should be possible to determine the source of any (quality) problem of an item, and it should be possible to find out where the other items with the same problem are located in the supply chain.

4.2 Information systems

The following demands can be made with regard to information systems that support traceability (Trienekens and Beulens, 2001):
- Identification of produce and products throughout the food chain. Identification aims at recognizing an item as a unique set of data. The identification function in a company provides items with unique codes (barcode, label, tag, etc.).
- Tracking of items: the determination of the ongoing location of items during their way through the supply chain. Tracking is pro-active, with the aim to know where an item is at a certain moment in time.
- Traceability of items. Tracing aims at defining the composition and the treatments an item has received during the various stages in the production life cycle. Tracing is re-active; it takes place after an occurrence (e.g. a food safety accident). Chain upstream (backward) tracing aims at determining the history of items and is used to determine the source of a problem of a defective item. Chain downstream (forward) tracing aims at the determination of the path through the supply chain an item has followed, based on, for example, a contaminated batch of raw materials (see figure 1).

Figure 1   Tracking and tracing (Van der Vorst et al., 2003)
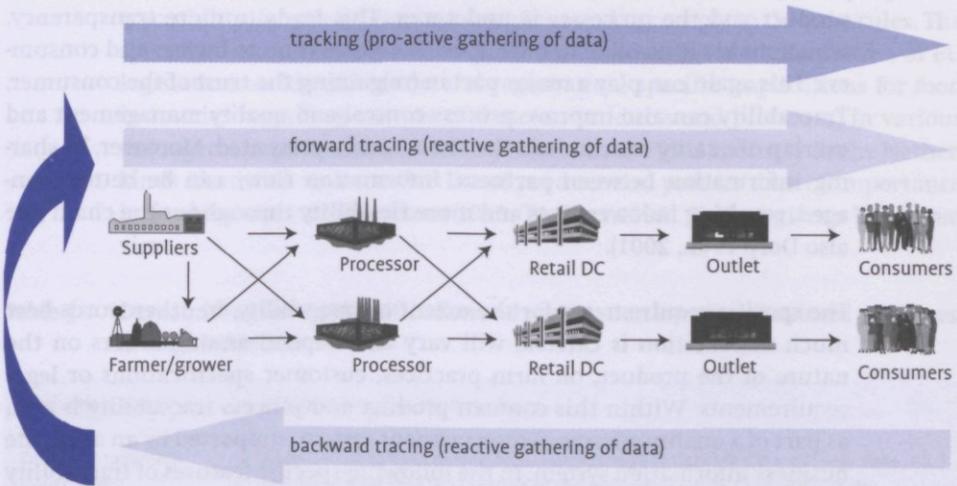
Product identification and product tracking and tracing each refer to a different set of requirements imposed on products and materials. They also have different drivers. The importance of identification is to be able to clearly distinguish one material or product from another during the manufacturing process, by means of tags, labels, routing sheets, colors, etc. Identification is typically done according to the supplier's established procedures.

In general business efforts regarding traceability are increasing. In this regard most stakeholders of the food chain recognize important benefits of traceability. Table 2 gives an overview.

Table 2   Benefits of traceability for different stakeholders (derived from: Food standards agency, 2002)

Consumer	Business	Government
– Protect food safety by effective product recall – Enable avoidance of specific foods and food ingredients, whether because of allergy, food intolerance or lifestyle choice	– Protect public health through the withdrawal of food products – Help prevent fraud where analysis cannot be used for authenticity – Enable control with regard to human and animal health in emergencies – Monitor and control for subsidy claims	– Comply with relevant legislation – Be able to take prompt action to remove products from sale – Be able to diagnose problems in production and pass on liability where relevant – Assure food products and maintain market and consumer confidence

Furthermore, traceability offers major advantages for logistics and quality management. First, a good tracing system offers possibilities to follow the product and the processes it undergoes. This leads to more transparency, which makes it possible to offer specific information to buyers and consumers. This again can play a major part in (re)gaining the trust of the consumer. Traceability can also improve process control and quality management and overlap of quality measures in the chain can be prevented. Moreover, by sharing information between partners, information flows can be better managed, resulting in lower costs and more flexibility throughout the chain (see also Dorp et al., 2001).

The specific requirements for the extent of traceability, in other words how much information is carried, will vary and depend among others on the nature of the product, on farm practices, customer specifications or legal requirements. Within this context, product and process traceability is seen as part of a quality assurance management system, supported by an adequate business information system. In the following specific features of traceability demands will be worked out in two examples: identification and registration demands in food industries and traceability demands in the beef chain.

4.2.1 Traceability systems in food industries

Production processes in food industries have a number of special characteristics that impact on the organization of food safety and complicate full traceability in the supply chain (Den Ouden et al., 1996; Trienekens, 1999; Hvolby and Trienekens 1999; Van der Vorst, 2000):

- Production processes usually consist of divergent processes combined with convergent processes (e.g. a pig is composed of more than one product; after decomposition for a number of products other ingredients are added). Splitting and mixing of lots are common activities in many food industries, which need control.
- Production yields are often uncertain. This can be explained by variations in composition, form, colour, etc. of raw materials and semi-manufactured products. Materials often have dynamic characteristics (e.g. changes in composition of dairy products, shrinking of meat products) and are perishable. This implies that product characteristics change over time.
- Recipes are often variable (one product can be based on more than one recipe and different raw materials can lead to similar products) and multilevel (one recipe can lead to more than one product: for example identical products in different packaging). Recipe management is a critical activity.
- Recycling of products or semi-finished products is common in food processing industries. In many cases end products that do not meet quality standards and, in part, waste or by-products can be recycled. Also, waste products have to be accounted for, because of environmental regulations, among other reasons.

Registration of process and product characteristics (e.g. composition, storage time, history of products) is essential for food industries, for the purpose of traceability, for production management and to comply to the new rules. The special characteristics have, in combination with the implementation of EU legislation on identification and registration, specific implications for food industries regarding the use of data (on products and processes) in various management processes. Research projects in the food industry in the Netherlands identified an extended list of product and process data of importance in food industries (Trienekens 1999, Twillert 1999). Table 3 gives a brief overview.

Table 3   Demands regarding identification and registration in various business processes in food industries

Production planning	– Registration of lot characteristics
Order management (purchasing)	– Registration of data during order entry (supplier, delivery data, delivery time, etc.)
	– Having insight into the location of the ordered goods in the supply chain
	– Registration in case of purchasing raw materials for the production of samples in R&D
Warehouse management	– Links between batch numbers of suppliers and lot numbers of food industry
	– Registration of data on lot characteristics during receipt
	– Lot traceability in case of splitting or mixing lots
	– Location control per lot
	– Reverse logistics: identification of raw materials lots that are returned from production
Manufacturing	– Registration of actual lot numbers that are used in production
	– Registration of process variables per 'batch'
	– Lot traceability in case of using more batches for one packaging order
Order management (sales)	– Registration of actual lot numbers that are sent to the customers
	– Registration of complaints
	– Using shelf-life restrictions in sales
Freight management	– Registration of data during order picking and truck loading (employee who picked the order, actual lot numbers per sales order line, departure time, departure temperature, etc.)
	– Being able to have insight into the distribution of trays over retail outlets
	– Tracking of pallets (or other returnable packaging materials) for finished goods

4.2.2   *Traceability demands to the beef chain*

Our second example is about the international beef supply chain. In the last years new labelling rules for beef products have come into effect in the EU to improve the traceability of beef and to provide more information to farmers and consumers. As of 1 September 2000 the following items had to be included in beef labelling: a reference number corresponding to the animal or group of animals, the country in which the animal was slaughtered, the country in which the animal was cut, and the reference number of the cutting enterprise. As of 1 January 2002, the country in which the animal was born, and in which it was raised was to be indicated as well. It is interesting to note that this regulation emphasizes the place of origin and not the manner in which the product is produced.

A disadvantage of this system is that such labelling could inadvertently serve as an advertisement for meat from certain member states. In addition, non-EU countries would also have to be identifiable. But these countries often lack good identification and registration (I&R) systems and well-functioning controlling agencies. Another disadvantage according to many cattle farmers is that these regulations will restrict their flexibility and decrease efficiency in various links in the chain, such as in buying, processing, transporting and selling. Groups of animals will have to be separated depending on their place of origin. This will lead in any case to less efficient use of the available capacity in the chain. For the consumer this may mean that meat will be sold more often pre-packaged with an identified country of origin.

Figure 2   The beef chain
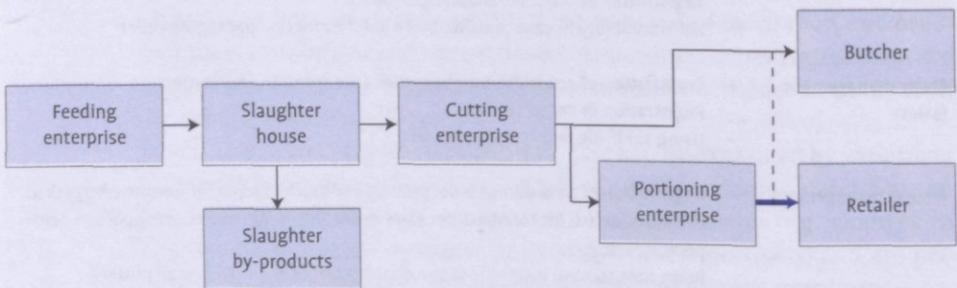
5   Discussion

In this last section two major challenges related to the foregoing will be discussed. These can be used as a basis for further study and discussion:

- Collaboration between national governments to achieve an international regulative system is crucial to obtain transparency in international food supply chains. However, current debates and disagreements in the European parliament and Council of Ministers about labelling shows that consensus between different EU countries about registration of properties modified are difficult to reach. The many differences between the USA, EU and other nations have also been subjects of negotiations within the Codex Alimentarius Commission (Barling, 2000). Especially supply chain companies in developing countries face difficulties in implementing safety and quality regulations as these companies often face poor infrastructural and institutional facilities. It may be expected that the sanitary and phyto-sanitary conditions under the WTO would accelerate the development of standards and compliance across trading countries. And while there has been progress, these standardization and compliance are far from complete.

- An increasing number of firms are offering various guarantees to their customers, concerning the use of pesticides or medications, animal welfare, and other 'ethical' variables, especially in Europe. For example, the Label Rouge program in France provides consumers with a guarantee that its poultry is raised under free range conditions. Others are the various organic certification protocols guaranteeing consumers that no artificial chemicals have been used in production. Moreover, although in most current European supply chains data are related to origin of produce and products, in the future new consumer demands may require the registration of new data. Important criteria for a sound identification and registration system are that it must be fraud-insensitive, and that data on the origin and history of a certain product must be able to be traced quickly and effectively. However, changes in information systems alone cannot bring the necessary integrity and auditability of information gathered and provided. These changes must be accompanied by other organizational changes in business processes and management.

From the previous parts in this chapter it may be clear that the business community at large faces a great number of challenges. Challenges derived from the need to satisfy consumer demands, to comply with rapidly changing legal requirements and business requirements, while ensuring low costs. Part of these requirements is that meeting these results is a 'license to produce'. Not being able to meet them, means loosing this license.

Case: consumer trust and food safety

The responsibility for the safety of food products, including the formulation of appropriate crisis response strategies, is seen by national and European governmental institutions as the joint responsibility of channel members: farmers, suppliers of raw materials, producers, transport and storage companies, and distributors, like retailers. Assuming shared responsibility, formulating strategies, and executing these strategies puts the burden on the co-operation between the channel members and their mutual relationships. The question is how co-operation in this field should be organized. Governmental institutions have an important, secondary role, which is mostly threefold: to regulate, to control, and to communicate. Channel members together develop quality assurance systems and traceability in food supply chains. However, does this answer consumers' concerns?

In order to formulate an effective course of action in the event of a food safety incident, channel members must at least understand the mechanisms consumers use to arrive at conclusions. These mechanisms have been analyzed in the KLICT-project 'Consumer trust and food safety'. In this project a conceptual model has been developed that describes the relationship between the perception of food safety incidents, the attribution of responsibility by consumers and the effects of possible responses by channel members. Food safety is closely related to perception: perception of risk, but also perception of blame and controllability in the event of an incident. In the event of an incident, consumers want to attribute responsibility to someone. One of the results is that the perceptions of controllability (the belief that the company involved could have acted differently) and stability (questioning whether the cause is temporary or permanent) influence the behaviour of people, for instance, their repurchasing intentions and complaint behaviour.

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