Food Control 32 (2013) 409–417

Contents lists available at SciVerse ScienceDirect

Food Control

journal homepage: www.elsevier.com/locate/foodcont

Review

Literature review: Does a common theoretical framework to implement food traceability exist?

Kine Mari Karlsen[a,*], Bent Dreyer[a], Petter Olsen[a], Edel O. Elvevoll[b]

[a] Nofima – Norwegian Institute of Food, Fisheries and Aquaculture Research, PO Box 6122, NO-9291 Tromsø, Norway
[b] Faculty of Biosciences, Fisheries and Economics, University of Tromsø, Breivika, N-9037 Tromsø, Norway

A R T I C L E I N F O

Article history:
Received 19 June 2012
Received in revised form
30 November 2012
Accepted 8 December 2012

Keywords:
Traceability
Theoretical framework
Implementation
Interdisciplinary research field
Food

A B S T R A C T

The purpose of this study was to identify whether a common theoretical framework with respect to implementation of food traceability exists. The literature review showed that no common understanding of the definitions and principles of traceability exists, nor is there a sound common theoretical framework with respect to implementation of food traceability. When no common theoretical framework exists, this affects the implementation process of traceability in the food industry. With a common theoretical framework, all traceability studies could have been more similar, and the implementation processes could have been more goal-oriented and efficient. Based on the review, it is clear that traceability is an interdisciplinary research field, and it spans the natural sciences as well as the social sciences. Further theoretical developments on implementation of food traceability are needed.

Contents

* Corresponding author. Tel.: +47 77 62 91 41; fax: +47 77 62 91 00.
E-mail address: kine.karlsen@nofima.no (K.M. Karlsen).

0956-7135/$ – see front matter
http://dx.doi.org/10.1016/j.foodcont.2012.12.011

1. Introduction

Traceability is a widely used concept, and in the last few decades various approaches within the traceability field have been studied. The ability to trace products means that the flow of material and information within a company and/or through a supply chain can be followed. The food scandals of the 1990s put traceability of food on the agenda. The outcome of these scandals was that traceability was incorporated in food regulations. Other areas of applications for traceability within the food industry have also been identified. Traceability can be useful to optimize production planning and scheduling, e.g. minimize waste and ensure optimal use of raw materials (Moe, 1998; Wang & Li, 2006). Traceability can also be used as a part of a competitive strategy (Canavari, Centonze, Hingley, & Spadoni, 2010) and to increase company coordination in supply chains (Banterle & Stranieri, 2008; Engelseth, 2009).

Previous studies have shown that information about food products and production processes can be lost internally within companies, as well as between companies in supply chains (Bertolini, Bevilacqua, & Massini, 2006; Donnelly, Karlsen, & Dreyer, 2012; Frederiksen, 2002; Frederiksen & Bremner, 2001; Karlsen & Senneset, 2006; Pálsson, Storøy, Frederiksen, & Olsen, 2000; Randrup et al., 2008). According to Frederiksen (2002), more detailed studies of each step in the supply chains are needed to better document each process. Such studies are important to improve the traceability of food. Jansen-Vullers, Van Dorp, and Beulens (2003) concluded that traceability requirements appear to be similar across the industries studied, but Ringsberg and Jönson (2010) found that no shared consensus regarding traceability exists.

The purpose of this study was to carry out a literature review of the traceability field to identify whether a common theoretical framework with respect to implementation of food traceability exists.

The paper is organized in the following way: First, the method used in this literature review is described. Second, the results from the literature review are presented. Last, the findings from this study are discussed.

2. Methodology

First, the literature review started with identifying the theoretical contributions to traceability. Then, empirical studies of food traceability were identified, after which an attempt was made to place these studies in their appropriate scientific fields. Finally, various methods applied in food traceability studies were identified.

The literature review was carried out by using the databases ProQuest Dialog, ScienceDirect, Web of Knowledge, and Google Scholar. The following combinations of terms were used in the literature search: 'traceability* + food', 'traceability* + definition', 'traceability* + food + implementation', 'traceability* + food + case study', 'traceability* + food + drivers', 'traceability* + food + cost + benefit', and 'traceability* + food + economic' and 'traceability* + food + method'.

2.1. Stage 1: identifying theoretical contributions to traceability

Different definitions of traceability as applied in the literature were studied in an attempt to identify whether a common understanding of traceability exists. Thereafter, the principles of traceability identified in the literature were studied in an attempt to identify similarities and differences. In addition, drivers and benefits of traceability in the food industry were identified. This knowledge is relevant when implementing food traceability. Drivers of traceability in other industries (e.g. automotive industry) were not included, due to the need to limit the literature search. In addition, these products are not affected by seasonal changes in terms of delivery of the input factor or shelf life in the same way many foodstuffs are.

2.2. Stage 2: identifying empirical findings regarding traceability

In stage 2, the empirical findings regarding traceability in the food industry were identified. First, we identified which of the drivers described in stage 1 were documented by empirical findings. Then, empirical findings of food traceability implementation were identified.

2.3. Stage 3: identifying scientific fields

In stage 3, an attempt was made to place the empirical findings identified in stage 2 into their appropriate scientific fields, documenting that traceability is studied in different fields and that this is a complex topic. This was a challenging task, because some of the articles identified span different scientific fields, and, in addition, some fields can include several other fields, which further compounds the issue. For example, supply chain management covers logistics, relationship marketing, and marketing channels (Engelseth, 2009). For this reason, we have simplified the relevant scientific fields as follows: economics: cost-benefit analyses of using traceability; marketing research: collecting information about markets or customers; supply chain management: the management and relationship of actors in food supply chains, as well as analyzing the production, distribution, and consumption of goods and services; quality management: planning, control, management, and improvement of quality; and engineering: the implementation and optimization of processes or systems, including information technology (IT).[1] These scientific fields were further categorized into natural sciences and social sciences.

2.4. Stage 4: identifying methods in food traceability studies

In stage 4, methods applied in food traceability studies were identified, documenting that different methods are being used in food traceability studies.

3. Results and discussion

The purpose of this study was to carry out a literature review of the traceability field to identify whether a common theoretical framework with respect to implementation of food traceability exists. This chapter presents the results from the literature review and discuss the findings.

3.1. Theoretical contributions on traceability

The main findings of the theoretical contribution on traceability are presented here, including definitions of traceability, principles of traceability and drivers of food traceability.

[1] IT is the area of managing technology, and includes, among other things, computer software, computer hardware, programming languages, and data constructs (Source: www.wikipedia.org). Information and communications technology (ICT) is an extended synonym for IT, and it includes technical equipments to handle and communicate information. Information systems (IS) is related to the combination of IT and the activities of people who handle technology. IT is the term used in this paper with respect to the use of technology to trace seafood products, in an effort to make it easier for the reader to read the text.

3.1.1. Definitions of traceability

Several definitions of traceability exist. The EU Common Food Law defines traceability as: '*...the ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution*' (EC-178/02, 2002).

The International Organization for Standardization (ISO) defines traceability as the: '*...ability to follow the movement of a feed or food through specified stage(s) of production, processing and distribution*' (ISO-22005:2007, 2007). The old ISO definition of traceability from 1994 defines traceability as the '*...ability to trace the history, application or location of an entity by means of recorded identifications*' (ISO, 1994).

Cheng and Simmons (1994) describe traceability as '*...the ability to retrace steps and verify that certain events have taken place*', while Opara and Mazaud (2001) present traceability as: '*...the collection, documentation, maintenance and application of information related to all processes in the supply chain in a manner that provides a guarantee to the consumer on the origin and life history of a product*'. Bollen, Riden, and Opara (2006) have yet another definition of traceability. Traceability is defined as '*...the means by which the information is provided*'. García, Santos, and Windels (2008), however, define traceability as the ability '*...to trace all the elements that can be considered relevant enough for the organization within a particular project or software product*'.

In the literature, the definition of traceability is also divided into different types. Lindwall and Sandahl (1996) split traceability into horizontal traceability and vertical traceability, where horizontal traceability is the ability '*...to trace correspondent items between different models*', and vertical traceability is the ability '*...to trace dependent items within a model*'. Moe (1998) has another description of the different types of traceability: chain traceability is the '*...ability to track a product batch and its history through the whole, or part, of a production chain from harvest through transport, storage, processing, distribution and sales*', whereas internal traceability is the '*...ability to trace...in one of the steps in the chain*'.

Terms often used to describe traceability are tracking, tracing, forward traceability and backward traceability. According to Dupuy, Botta-Genoulaz, and Guinet (2005), tracing is the '*...the ability, in every point of the supply chain, to find origin and characteristics of a product from one or several given criteria*', and tracking is the '*...the ability, in every point of the supply chain, to find the localization of products from one or several given criteria*'. Schwagele (2005) describes tracking as the '*...the ability to follow the path of an item as it moves downstream through the supply chain from the beginning to the end*', and tracing as the '*...the ability to identify the origin of an item or group of items, through records, upstream in the supply chain*'. According to Jansen-Vullers et al. (2003), tracking is: '*...a method of following an object through the supply chain and registering any data considered of any historic or monitoring relevance*', forward traceability is '*...the exploration of where-used relations between objects*', and backward traceability is '*...the exploration of the where-from relation between objects*'.

Several definitions of traceability exist in different industries, which can make the term traceability confusing. Still, several of these definitions share certain common characteristics: the ability to '*trace*'/'*follow*' the '*movement*'/'*path*' of an entity, X. X can be defined as '*steps*', '*object*', '*batch*', '*food*', '*feed*'/'*food-producing animal*', '*substance*', or '*item*'. The differences between many of these definitions relate to the entity X, in other words what to trace. This is in agreement with Kirova, Kirby, Kothari, and Childress (2008), who point out that several complementary definitions of traceability exist. Olsson and Skjöldebrand (2008), on the other hand, state that traceability is a complex field, thus giving rise to several different definitions of traceability. Another common characteristic revealed in the review is the ability to trace information, e.g. '*tracing*'/'*registering*' '*information*'/'*data*'. Such information can be the history, application or location of all processes in the supply chain, or the origin and characteristics of a product.

Olsen and Aschan (2010) state that the International Organization for Standardization (ISO) definition of traceability (ISO, 1994) is the most precise definition in terms of product traceability. This definition is the only one of the identified definitions describing how traceability can be achieved – '*...by means of recorded identifications*'. In other words, product and process information must be recorded in a systematic way in order to be traceable; in particular, information received by a company on the raw material must be recorded and linked to the production batch, which in turn must be linked to the shipped products. Only then it is possible to retrieve information on raw materials in the finished products.

3.1.2. Principles of traceability

Several published studies describing principles of traceability in the food industry and other industries have been found. In the below sections, different views of traceability are described.

According to Kim, Fox, and Gruninger (1995), traceable resource unit (TRU) is the name given to an entity that is traceable. TRUs are entities with similar characteristics that have gone through the same processes. Traceability is based on a clearly defined relationship between these units.

Moe (1998) follows this approach, but specifically points out that traceability is based on unique identification of the products. Identifying TRUs and activities is necessary in order to trace a product. TRUs can be described according to weight, volume, etc., and activities can be described according to type and time/duration, such as processing, transportation and storage.

Storøy et al. (2008) take a similar view of traceability, but describe it in more detail. They state that trade units must be uniquely identified, that additional information must be linked to these units via the unique identification number, and that all transformations (split and joins) must be recorded. Transformations are points where the resources are mixed, transferred, added, and/or split up (Derrick & Dillon, 2004). The relationships between traceable units can be one-to-one, many-to-one, one-to-many or many-to-many. Identifying traceable units and transformation relationships is the key to tracing a product internally and/or in supply chains (Storøy et al., 2008). Product information can be linked to the identification number of traceable units.

This is line with the TraceFish standards (CEN, 2003a, 2003b), ISO-12875:2011 (2011), ISO-12877:2011 (2011) and the TraceFood framework (2012): Prerequisites for achieving traceability are unique identification of traceable units and records of transformations. The TraceFish standards are specifications of the information to be recorded in captured fish and farmed fish distribution chains, and TraceFood is a framework comprising principles, standards, and methods for implementing traceability in the food industry. The TraceFood framework (2012) divides traceable units into 1) batch, 2) trade unit (TU), and 3) logistic unit (LU): A batch is '*...a quantity that has gone through the same process at a specific place and time period before moving to another place. A production batch is the traceable unit that raw materials and ingredients go into before they are transformed into products placed in new Trade Units and Logistic Units*', a trade unit is '*...the smallest traceable unit that is exchanged between two parties in the supply chain*', and a logistic unit is '*...the smallest traceable unit that is exchanged between two parties in the supply chain*'.

According to Opara (2003), traceability consists of six elements: 1) '*product traceability*' (which determines the physical location of a product), 2) '*process traceability*' (which ascertains the type and sequences of activities that have affected the product), 3) '*genetic* *traceability*' (which determines the genetic constitution of the product), 4) '*input traceability*' (which determines the type and origin of inputs), 5) '*disease and pest traceability*' (which traces the epidemiology of pests and biotic hazards), and 6) '*measurement traceability*' (which relates individual measurements results through an unbroken chain of calibrations to accepted reference standards). '*Process traceability*' is to some degree similar to '*activity*', as defined by Moe (1998). Moe (1998) did not include input, hazards, or measurements in her model.

Bianchi, Fasolino, and Visaggio (2000) have yet another view of traceability. They divide traceability into three dimensions: 1) '*vertical and horizontal traceability*' (whether the interconnection between items is in the same software model or in different models), 2) '*explicit or implicit links*' (types of links between items), and 3) '*structural or cognitive links*' (more detail description of the implicit link). The focus here is software maintenance and traceability model comprehension. It is clear that this view of traceability is quite different to the other descriptions of traceability. The similarity of these views, however, is that the links between the 'Zs' must be traceable. 'Z' can, for example, be a product or a class in a Unified Modeling Language (UML) class diagram.

The below section describes the drivers of food traceability identified in the literature.

3.1.3. Drivers of food traceability

In the literature, ten drivers of food traceability have been identified, see Fig. 1 modified from Olsen (2009): 1) legislation (Bollen, 2004; Opara & Mazaud, 2001; Schröder, 2008; Schwagele, 2005; Sebestyen et al., 2008; Senneset, Forås, & Fremme, 2007; Skoglund & Dejmek, 2007; Smith et al., 2005; Thakur & Hurburgh, 2009; Thompson, Sylvia, & Morrissey, 2005; Wang & Li, 2006), 2) food safety (Elbers et al., 2001; Moe, 1998), 3) quality (Frederiksen, Østerberg, Silberg, Larsen, & Bremner, 2002; Galvão, Margeirsson, Garate, Viðrsson, & Oetterer, 2010; Mai, 2010; Riden & Bollen, 2007; Viaene & Verbeke, 1998; Wang & Li, 2006; Zadernowski, Verbeke, Verhè, & Babuchowski, 2001), 4) sustainability (Roheim & Sutinen, 2006; Schmid & Connelly, 2009), 5) welfare (Madec, Geers, Vesseur, Kjeldsen, & Blaha, 2001), 6) certification (Bevilacqua, Ciarapica, & Giacchetta, 2009; Frosch, Randrup, & Frederiksen, 2008; Roheim & Sutinen, 2006; Schmid & Connelly, 2009), 7) competitive advantages (Sant'Ana, Ducatti, & Ramires, 2010), 8) chain communication (Frederiksen et al., 2002), 9) bioterrorist threats (Olson, 2005; Thakur, Wang, & Hurburgh, 2010; Thompson et al., 2005), and 10) production optimization (Ruiz-Garcia, Steinberger, & Rothmund, 2010).

Fig. 1. Modified from Olsen (2009): model of drivers of traceability in the food industry.

Moe (1998) describes drivers of food traceability in more detail by specifying the benefits of internal traceability and chain traceability. According to Moe (1998), the benefits of internal traceability are as follows: better planning to optimize use of resources, improved process control, correlation of product data with data on characteristics and processes, cause-and-effect-indicators to satisfy product standards, avoiding mixing high- and low-quality materials, ease of information retrieval in quality management audits, and better foundations for implementing information technology solutions in control and management systems. The benefits of chain traceability are as follows: satisfaction of legal requirements, avoiding repeated measurements, chance to market special raw material or product features, better incentives for maintaining inherent quality of raw materials, efficient recall procedures, and better quality and process control.

The level of detail in information may be higher within a company (internal traceability) than in a supply chain (chain traceability), because it is assumed that the customer is only interested in a limited number of data elements (Moe, 1998). Using information for the purposes of quality control and process optimization will require more details.

The below section presents empirical findings on traceability.

3.2. Empirical findings on food traceability

The main empirical findings on traceability are presented below, including drivers of food traceability and implementation of food traceability.

3.2.1. Empirical findings on drivers of food traceability

Several studies with empirical data on the drivers of food traceability were identified. The majority of these studies were carried out in relation to food safety (Hernández-Jover, Schembri, Toribio, & Holyoake, 2009; Regattieri, Gamberi, & Manzini, 2007), quality (Galvão et al., 2010; Mai, Bogason, Arason, Arnason, & Matthiasson, 2010), competitive advantages (Canavari et al., 2010; Van Rijswijk, Frewer, Menozzi, & Faioli, 2008), chain communication (Engelseth, 2009; Wang, Li, & O'Brien, 2009), and production optimization (Huang & Yang, 2009; Margeirsson, 2008). No empirical data was found regarding bioterrorist threats.

Several of these drivers affect each other. For example, certification traceability schemes can give access to the market and can thus represent a competitive advantage (Manos & Manikas, 2010), and animal health documentation can be used for marketing purposes (Schulz & Tonsor, 2010). It is likely that this model will be expanded in the near future when other drivers of food traceability are identified.

3.2.2. Empirical findings on implementation of traceability

Several empirical studies into implementation of food traceability were identified: Billo and Bidanda (1998) presented a structured approach for designing and implementing a traceability system for a variety of industries. Madec et al. (2001) studied electronic identification and data recording for pigs. Frederiksen et al. (2002) developed an Internet-based traceability system for fresh fish. Mousavi, Sarhadi, Fawcett, Bowles, and York (2005) presented a tracking and traceability solution using a novel material handling system for the meat-processing industry. Thompson (2005) designed and developed an onboard electronic traceability system for albacore tuna. Senneset et al. (2007) studied challenges regarding implementation of electronic chain traceability for farmed salmon. Regattieri et al. (2007) described the integration of barcodes and radio frequency identification (RFID) tag technology to trace cheese. Hernández-Jover et al. (2009) evaluated the implementation of traceability and food safety requirements for fresh vegetables. Abad et al. (2009) developed RFID tags for real-time traceability and cold chain monitoring for fresh fish. Huang and Yang (2009) described an RFID tag and quick-response code-based system for in-house management of shrimp. Karlsen, Sørensen, Forås, and Olsen (2011) studied critical criteria in the implementation of electronic traceability in a fresh fish supply chain.

The study carried out by Karlsen, Sørensen et al. (2011) shows that motivation is a critical factor for implementing traceability, and that motivation is closely linked to the identification of benefits and costs associated with traceability. Consequently, identifying costs and benefits is essential when companies decide to implement traceability.

Several studies containing empirical data on costs and benefits in using traceability were identified: Disney, Green, Forsythe, Wiemers, and Weber (2001) studied cost-benefit analyses of animal identification for disease prevention and control. The results show that better animal identification may provide sufficient economic benefits with regard to the consequences of foreign animal diseases. Golan et al. (2004) investigated traceability in the US food supply. In this study, it was concluded that companies balance the private costs and benefits of traceability to identify the optimal level of traceability. Souza-Monteiro and Caswell (2004) studied the economic impacts of mandatory and voluntary traceability systems for beef in the EU, Japan, Australia, Brazil, Argentina, Canada, and the United States. The findings show that the economic implications of these systems are just beginning to be played out. Sparling, Henson, Dessureault, and Herath (2006) studied costs and benefits of traceability in the Canadian dairy-processing sector. In this study, it was documented the motivated benefits of traceability before implementation and perceived benefits of traceability after implementation were different. Can-Trace (2007) investigated the costs of using traceability for animals (sheep, cattle, and hogs). The results show the costs of traceability are highly variable due to herd and operation size, species, operational practices and infrastructure, and the complexity of the animal identification system. Mai et al. (2010) studied benefits of using traceability in fish supply chains. Improving supply chain management was identified as the most important benefits of traceability.

3.3. Scientific fields identified in traceability studies

The scientific fields identified in traceability studies show that traceability has been studied in several different scientific fields: economics, marketing research, supply chain management, quality management, and engineering (Fig. 2).

In the research field of economics, several cost-benefits analyses using traceability in the food industry have been carried out, e.g. Disney et al. (2001), and Sparling et al. (2006).

Within the marketing research field, several different perspectives have been applied in traceability studies, such as Van Rijswijk et al. (2008), who described consumer perceptions of traceability, and Canavari et al. (2010), who studied traceability as a part of competitive strategy in the fruit supply chain.

In the supply chain management research field, traceability has been an issue in several different studies: logistics management, inventory management, risk management, supply-side management, product differentiation, distribution systems, and decision support systems. For example Mai et al. (2010) studied benefits of traceability in fish supply chains. In this study, the following benefits were identified: improving supply chain management, increase the ability to retain existing customers, product quality improvement; product differentiation; and reduction of customer complaints. Arason et al. (2010) described decision support systems for the food industry where traceability can be used to get access to relevant data. Banterle and Stranieri (2008) studied the consequences of voluntary traceability systems in supply chain relationships for Italian companies. The results show an increased vertical coordination for companies that used oral agreements.

In the quality management field, quality control, quality improvement, quality assurance systems, and quality management systems have been studied. For example Frederiksen (2002) studied cooperation in Danish fresh fish supply chains with focus on quality assurance. The findings show lack of cooperation between the different steps in the studied supply chain. Galvão et al. (2010) investigated how different factors in Icelandic cod fishing can influence the quality of raw materials by using traceability. In this study, it was documented there is a correlation between the numbers of parasites in the fillets and location of the fishing ground.

In the research field of engineering, several implementation studies of food traceability have been identified, as presented in

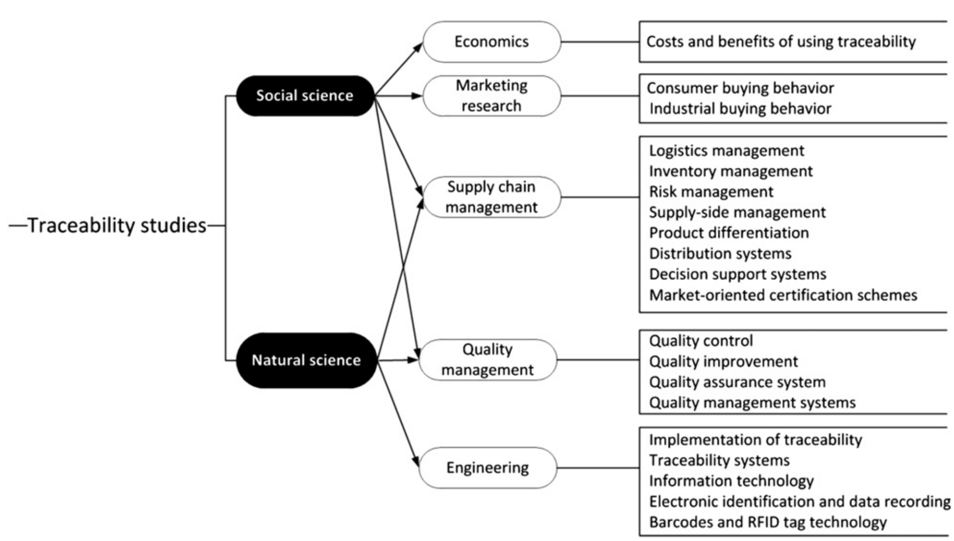

Fig. 2. Identified scientific fields in empirical studies of food traceability.

Section 3.2.2. These studies cover various aspects of traceability implementation, traceability systems, information technology, electronic identification and data recording, barcodes, and RFID tag technology.

The below section describes identified methods applied in traceability studies.

3.4. Identified methods in traceability studies

Methods identified in food traceability studies show that different types of methods have been used to study traceability (Fig. 3): action research (Bollen, Ridena, & Cox, 2007; Karlsen, Sørensen et al., 2011; Senneset et al., 2007), interviews (Chryssochoidis, Karagiannaki, Pramatari, & Kehagia, 2009; Donnelly, Karlsen, & Olsen, 2008; Engelseth, 2009), focus groups (Chrysochou, Chryssochoidis, & Kehagia, 2009; Kehagia, Chrysochou, Chryssochoidis, Krystallis, & Linardakis, 2007), surveys (Banterle & Stranieri, 2008; Schulz & Tonsor, 2010; Wang et al., 2009), traceability control mechanisms (Abad et al., 2009; Moretti, Turchini, Bellagama, & Caprino, 2003; Peres, Barlet, Loiseau, & Montet, 2007; Pèrez-Villarreal, Amàrita, Bald, Pardo, & Sagardia, 2008; Turchini, Quinn, Jones, & Gooley, 2009), case studies (Donnelly, Karlsen, & Olsen, 2009; Manos & Manikas, 2010), modeling (Jensen, Nielsen, Larsen, & Clausen, 2010; Lo Bello, Mirabella, & Torrisi, 2004; Pouliot & Sumner, 2008; Thakur & Donnelly, 2010), simulation (Disney et al., 2001; Skoglund & Dejmek, 2007), and choice of architecture (Senneset, Midtstraum, Forås, Vevle, & Mykland, 2010; Voulodimos, Patrikakis, Sideridis, Ntafis, & Xylouri, 2010). Traceability control mechanisms are defined as '…*methods and instruments used for authentication and testing that what we receive is what the documentation says*'. Many of these studies combine several different methods to study a specific aspect of traceability, such as Hobbs, Bailey, Dickinson, and Haghiri (2005), Starbird and Amanor-Boadu (2006), Zhang, Zhang, Liu, Fu, and Mu (2010) and Karlsen and Olsen (2011).

3.5. Does a common theoretical framework exist?

Based on the literature review, it is clear that no common theoretical framework for implementing food traceability exists. An interesting question is: Why do we have different views on traceability definitions and principles? One possible explanation is that the traceability field has developed in different directions in different scientific fields, as documented in the literature review. This is further supported by looking at the focus of the published traceability studies in different scientific journals: Arana, Soret, Lasa, and Alfonso (2002) studied meat traceability using deoxyribonucleic acid (DNA) markers, published in 'Meat Science'. Asenslo and Montero (2008) carried out an analysis of fresh labeling in Spanish fish retail shops, published in 'Food Control'. Kehagia et al. (2007) studied European consumer perceptions of traceability, published in 'Sociologia Rualis'. Bechini, Cimino, Marcelloni, and Tomasi (2008) studied patterns and technologies for enabling supply chain traceability through collaborative e-business, published in 'Information and Software Technology'. Donnelly et al. (2008) created standardized data lists for traceability of honey published in 'Int. J. Metadata, Semantics and Ontologies'. Thakur et al. (2010) described a multi-objective optimization approach to balancing cost and traceability in bulk handling, published in 'Journal of Food Engineering'. Mai et al. (2010) studied benefits of traceability in fish supply chains, published in 'British Food Journal'.

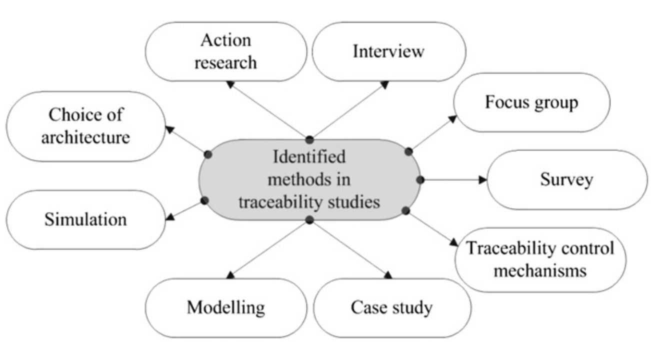

Fig. 3. Identified methods for measuring food traceability. Traceability control mechanisms are defined as '…*methods and instruments used for authentication and testing that what we receive is what the documentation says*' (Tracefood, 2012).

Another interesting question to ask is: What are the consequences of this when implementing food traceability? The lack of a common theoretical framework can cause problems for food companies in deciding whether or not to implement traceability. There is a need to document the benefits and costs of using traceability before a company is motivated to carry out such implementation.

If a food company decides to implement traceability for their products, they need to decide which traceability level to implement, so-called granularity (see Karlsen, Donnelly, and Olsen (2011) and Karlsen, Dreyer, Olsen, and Elvevoll (2012) for more details), internal traceability vs. chain traceability, electronic vs. paper-based traceability, and which architecture to use. Another problem stemming from a lack of a common theoretical framework is how to measure and evaluate the implemented traceability system.

Developing a common theoretical framework is a challenging task, given the complexity of the traceability field. This can be illustrated by taking a closer look at the different phases in implementation of traceability, and where the identified scientific fields are relevant. The implementation process can be split into three phases: before, during and after implementation of traceability. In the 'before' phase, identifying the benefits and costs of using traceability is important, and is close connectedly linked to motivation. As documented, motivation is a critical criterion for successful implementation of traceability (Karlsen et al., 2011a). Motivation can be relevant for the following scientific fields: marketing research, supply chain management, quality management, and economics. When the benefits exceed the costs of using traceability, motivation will increase, in turn of increasing the change of successfully implementing traceability.

During the implementation process, the engineering research field is relevant. Many traceability studies focus on engineering. This is in line with Meuwissen, Velthuis, Hogeveen, and Huirne (2003), who state that the general focus is on the technical characteristics of traceability. The literature review shows that there is a lack of empirical documentation as to the importance of people in the implementation of food traceability. The human factor is critical in the implementation process, and several scientific fields should thus be included in the implementation of traceability, not just engineering.

In the 'after' phase, the following research fields are relevant to the documentation of different aspects of traceability in the food industry: marketing research, supply chain management, quality management, and economics.

It is clear that further theoretical developments on implementation of food traceability are needed, but which strategy to use to come up with a common definition and understanding of food traceability? One step in the right direction is to compare the different definitions and principles, identify similarities and differences. The strengths and weaknesses of the different approaches should also be discussed. An example of such study has been carried out by Olsen and Borit (2012), where different definitions of food traceability are compared.

In addition, it is recommended that the scientists discuss the used research process and approach (deductive, inductive or abductive) in detail when developing and testing the theory. The deductive approach tests the theory, the inductive approach develops theory, and the abductive approach suggests new theories (Spens & Kovàcs, 2005). All these three approaches are benefit able to use when developing and testing theory due to their weaknesses and strengths.

4. Conclusion

The purpose of this study was to carry out a literature review of the traceability field to identify whether a common theoretical framework with respect to implementation of food traceability exists. Several different definitions and principles of traceability are currently being applied, which can make the term traceability and the concept of traceability confusing. The traceability field has developed in different directions, and several of the traceability studies in the food industry cover different scientific fields and apply different scientific methods. Traceability is an interdisciplinary research field, and it spans the natural sciences as well as the social sciences.

From the literature review it is clear that differences do exist between the definitions of traceability as applied in the IT industry and the food industry, e.g. '*...to trace ... within a model...*' and '*... to trace in one of the steps in the chain...*'. The literature review has shown that no common understanding of the definitions and principles of traceability exist, nor is there a common theoretical framework with respect to implementation of food traceability.

4.1. Implications

The findings in this study have several theoretical and practical implications. In the below sections, these implications are discussed in more detail.

4.1.1. Theoretical implications

Further theoretical developments on the implementation of food traceability are needed. It is important to better understand why implementations of food traceability succeed or fail. Theoretical contributions related to how costs and benefits are distributed in the food supply chain are crucial to understanding why some parts of the supply chain choose to implement traceability while other parts do not.

4.1.2. Practical implications

When no common theoretical framework exists, this can affect the implementation process of traceability in the food industry. With a common theoretical framework, all traceability studies could have been more similar, and the implementation processes could have been more goal-oriented and efficient. In addition, there would probably have been fewer misunderstandings between the people involved in the implementation of food traceability.

Acknowledgments

The authors would like to thank Innovation Norway, the Norwegian Seafood Research Fund, and the Norwegian Ministry of Fisheries and Coastal Affairs for funding this research.

References

Abad, E., Palacio, F., Nuin, M., Zárate, A. G. D., Juarros, A., Gómez, J. M., et al. (2009). RFID smart tag for traceability and cold chain monitoring of foods: demonstration in an intercontinental fresh fish logistic chain. *Journal of Food Engineering, 93*(4), 394–399.

Arana, A., Soret, B., Lasa, I., & Alfonso, L. (2002). Meat traceability using DNA markers: application to the beef industry. *Meat Science, 61*(4), 367–373.

Arason, S., Ásgeirsson, E. I., Margeirsson, B., Margeirsson, S., Olsen, P., & Stefánsson, H. (2010). Decision support systems for the food industry. In J. Kacprzyk, & L. C. E. Jain (Eds.), *Handbook on decision making* (pp. 295–315). Berlin, German: Springer.

Asenslo, L., & Montero, A. (2008). Analysis of fresh fish labelling in Spanish fish retail shops. *Food Control, 19*(8), 795–799.

Banterle, A., & Stranieri, S. (2008). The consequences of voluntary traceability system for supply chain relationships. An application of transaction cost economics. *Food Policy, 33*(6), 560–569.

Bechini, A., Cimino, M. G. C. A., Marcelloni, F., & Tomasi, A. (2008). Patterns and technologies for enabling supply chain traceability through collaborative e-business. *Information and Software Technology, 50*(4), 342–359.

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

Bevilacqua, M., Ciarapica, F. E., & Giacchetta, G. (2009). Business process reengineering of a supply chain and a traceability system: a case study. *Journal of Food Engineering, 93*(1), 13–22.

Bianchi, A., Fasolino, A. R., & Visaggio, G. (2000). An exploratory case study of the maintenance effectiveness of traceability models. In *Proceedings IWPC 2000. 8th International workshop on program comprehension* (pp. 149–158). Limerick: Ireland The Institute of Electrical and Electronics Engineers (IEEE).

Billo, R. E. & Bidanda, B. (1998). Modeling effective material tracking systems a case study in wireless technology. In *Industrial engineering solutions '98, conference proceedings* (pp. 10–17).

Bollen, A. F. (2004). Traceability in fresh produce supply chains. In D. J. E. Tanner (Ed.), *ISHS acta horticulturae 687: International conference postharvest unlimited down under 2004* (pp. 279–288). Sydney, Australia.

Bollen, A. F., Ridena, C. P., & Cox, N. R. (2007). Agricultural supply system traceability, part 1: role of packing procedures and effects of fruit mixing. *Biosystems Engineering, 98*, 391–400.

Bollen, F. P., Riden, C. P., & Opara, L. U. (2006). Traceability in postharvest quality management. *International Journal of Postharvest Technology and Innovation, 1*(1), 93–105.

Can-Trace. (2007). *Cost of traceability in Canada: Developing a measurement model*. Report March 2007. Ottawa, Canada: Agriculture and Agri-Food Canada, ISBN 978-0-662-46769-4.

Canavari, M., Centonze, R., Hingley, M., & Spadoni, R. (2010). Traceability as part of competitive strategy in the fruit supply chain. *British Food Journal, 112*(2), 171–184.

CEN. (2003a). *CEN workshop agreement 14659 – Traceability of fishery products – Specification of the information to be recorded in farmed fish distribution chains*. Brussels, Belgium: European Committee for Standardization.

CEN. (2003b). *CEN workshop agreement 14660 – Traceability of fishery products – Specification of the information to be recorded in captured fish distribution chains*. Brussels, Belgium: European Committee for Standardization.

Cheng, M. J., & Simmons, J. E. L. (1994). Traceability in manufacturing systems. *International Journal of Operations & Production Management, 14*(10), 4–16.

Chrysochou, P., Chryssochoidis, G., & Kehagia, O. (2009). Traceability information carriers. The technology backgrounds and consumers' perceptions of the technological solutions. *Appetite, 53*(3), 322–331.

Chryssochoidis, G., Karagiannaki, A., Pramatari, K., & Kehagia, O. (2009). A cost-benefit evaluation framework of an electronic-based traceability system. *British Food Journal, 111*(6–7), 565–582.

Derrick, S., & Dillon, M. (2004). *A guide to traceability within the fish industry*. Copenhagen (Denmark): SIPPO, Eurofish, Humber Institute of Food & Fisheries, ISBN 1-900134-18-7.

Disney, W. T., Green, J. W., Forsythe, K. W., Wiemers, J. F., & Weber, S. (2001). Benefit-cost analysis of animal identification for disease prevention and control. *Revue Scientifique Et Technique De L Office International Des Epizooties, 20*(2), 385–405.

Donnelly, K. A.-M., Karlsen, K. M., & Dreyer, B. (2012). A simulated recall study in five major food sectors. *British Food Journal, 114*(7), 1016–1031.

Donnelly, K. A.-M., Karlsen, K. M., & Olsen, P. (2008). Creating standardised data lists for traceability: a study of honey processing. *International Journal of Metadata, Semantics and Ontologies, 3*(4), 283–291.

Donnelly, K. A.-M., Karlsen, K. M., & Olsen, P. (2009). The importance of transformations in traceability – a case study of lamb and lamb products. *Meat Science, 83*(1), 69–73.

Dupuy, C., Botta-Genoulaz, V., & Guinet, A. (2005). Batch dispersion model to optimise traceability in food industry. *Journal of Food Engineering, 70*(3), 333–339.

EC-178/02. (2002). *Regulation (EC) No 178/2002 of the European parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establish the European food safety authority and laying down procedures in matters of food safety*. The European Parliament and the Council of the European Union.

Elbers, A. R. W., Moser, H., Ekker, H. M., Crauwels, P. A. A., Stegeman, J. A., Smak, J. A., et al. (2001). Tracing systems used during the epidemic of classical swine fever in the Netherlands, 1997–1998. *Revue Scientifique Et Technique De L Office International Des Epizooties, 20*(2), 614–629.

Engelseth, P. (2009). Food product traceability and supply network integration. *Journal of Business & Industrial Marketing, 24*(5/6), 421–430.

Frederiksen, M. (2002). *Fresh fish with traceable quality*. Doctoral thesis. Lyngby, Denmark: Danish Institute of Fisheries Research, Department of Seafood Research, Department of Biotechnology, Technical University of Denmark.

Frederiksen, M. T., & Bremner, A. (2001). Fresh fish distribution chains. An analysis of three Danish and three Australian chains. *Food Australia, 54*(4), 117–123.

Frederiksen, M., Østerberg, C., Silberg, S., Larsen, E., & Bremner, A. (2002). Info-fisk: development and validation of an Internet based traceability system in a Danish domestic fresh fish chain. *Journal of Aquatic Food Product Technology, 11*(2), 13–34.

Frosch, S., Randrup, M., & Frederiksen, M. (2008). Opportunities for the herring industry to optimize operations through information recording, effective traceability systems, and use of advanced data analysis. *Journal of Aquatic Food Product Technology, 17*(4), 387–403.

Galvão, J. A., Margeirsson, S., Garate, C., Viðrsson, J. R., & Oetterer, M. (2010). Traceability system in cod fishing. *Food Control, 21*(10), 1360–1366.

García, H., Santos, E., & Windels, B. (2008). Traceability management architectures supporting total traceability in the context of software engineering. In *Varna, Bulgaria: Sixth International conference in information research and application – i. Tech 2008* (pp. 17–23).

Golan, E., Krissoff, B., Kuchler, F., Calvin, L., Nelson, K., & Price, G. (2004). *Traceability in the US food supply: Economic theory and industries studies*. Agricultural Economic Report Number 830. Washington, DC: United States Department of Agriculture.

Hernández-Jover, M., Schembri, N., Toribio, J. A., & Holyoake, P. (2009). Evaluation of the implementation of new traceability and food safety requirements in the pig industry in Eastern Australia. *Australian Veterinary Journal, 87*(10), 387–396.

Hobbs, J. E., Bailey, D. V., Dickinson, D. L., & Haghiri, M. (2005). Traceability in the Canadian red meat sector: do consumers care? *Canadian Journal of Agricultural Economics–Revue Canadienne D Agroeconomie, 53*(1), 47–65.

Huang, E., & Yang, J.-C. (2009). The integration of seafood traceability systems for shrimp value chain systems. *International Journal of Computers, 3*(2), 201–210.

ISO. (1994). *Quality management systems – Fundamentals and vocabulary ISO*. International Organization for Standardization.

ISO-12875:2011. (2011). *Traceability of finfish products – Specification on the information to be recorded in captured finfish distribution chains*. International Organization for Standardization.

ISO-12877:2011. (2011). *Traceability of finfish products – Specification on the information to be recorded in farmed finfish distribution chains*. International Organization for Standardization.

ISO-22005:2007. (2007). *Traceability in the feed and food chain – General principles and basic requirements for system design and implementation*. International Organization for Standardization.

Jansen-Vullers, M. H., Van Dorp, C. A., & Beulens, A. J. M. (2003). Managing traceability information in manufacture. *International Journal of Information Management, 23*(5), 395–413.

Jensen, T. K., Nielsen, J., Larsen, E. P., & Clausen, J. (2010). The fish industry – towards supply chain modeling. *Journal of Aquatic Food Product Technology, 19*, 214–226.

Karlsen, K. M., & Olsen, P. (2011). Validity of method for analysing critical traceability points. *Food Control, 22*(8), 1209–1215.

Karlsen, K. M., Donnelly, K. A. M., & Olsen, P. (2011). Granularity and its importance for traceability in a farmed salmon supply chain. *Journal of Food Engineering, 102*(1), 1–8.

Karlsen, K. M., Dreyer, B., Olsen, P., & Elvevoll, E. O. (2012). Granularity and its role in implementation of seafood traceability. *Journal of Food Engineering, 112*(1–2), 78–85.

Karlsen, K. M., & Senneset, G. (2006). Traceability: simulated recall of fish products. In J. Luten, J. Oehlenscghlager, C. Jacobsen, K. Bekaert, & A. Særbo (Eds.), *Seafood research from fish to dish, quality, safety and processing of wild and farmed fish* (pp. 251–262). The Netherlands: Wageningen Academic Publishers.

Karlsen, K. M., Sørensen, C. F., Forås, F., & Olsen, P. (2011). Critical criteria when implementing electronic chain traceability in a fish supply chain. *Food Control, 22*(8), 1339–1347.

Kehagia, O., Chrysochou, P., Chryssochoidis, G., Krystallis, A., & Linardakis, M. (2007). European consumers' perceptions, definitions and expectations of traceability and the importance of labels, and the differences in these perceptions by product type. *Sociologia Ruralis, 47*, 400–416.

Kim, H. M., Fox, M. S., & Gruninger, M. (1995). An ontology for enterprise modelling. In *Proceedings of the fourth Workshop on Enabling Technologies: Infrastructure for Collaborative Enterprises WET ICE '95* (pp. 105–116). Los Albamitos, USA: The Institute of Electrical and Electronics Engineers (IEEE) Computer Society Press.

Kirova, V., Kirby, N., Kothari, D., & Childress, G. (2008). Effective requirements traceability: models, tools, and practices. *Bell Labs Technical Journal, 12*(4), 143–157.

Lindwall, M., & Sandahl, K. (1996). Practical implications of traceability. *Software – Practice and Experience, 26*(10), 1161–1180.

Lo Bello, L., Mirabella, O., & Torrisi, N. (2004). Modelling and evaluating traceability systems in food manufacturing chains. In *13th IEEE International Workshops on Enabling Technologies: Infrastructure for Collaborative Enterprises (WETICE'04)* (pp. 173–179).

Madec, F., Geers, R., Vesseur, P., Kjeldsen, N., & Blaha, T. (2001). Traceability in the pig production chain. *Revue Scientifique Et Technique De L Office International Des Epizooties, 20*(2), 523–537.

Mai, T. T. N. (2010). *Enhancing quality management of fresh fish supply chain through improved logistics and ensured traceability*. Doctoral thesis. Reykjavik, Iceland: Faculty of Food Science and Nutrition, School of Health Sciences, University of Iceland.

Mai, N., Bogason, S. G., Arason, S., Arnason, S. V., & Matthiasson, T. G. (2010). Benefits of traceability in fish supply chains – case studies. *British Food Journal, 112*(8–9), 976–1002.

Manos, B., & Manikas, I. (2010). Traceability in the Greek fresh produce sector: drivers and constraints. *British Food Journal, 112*(6), 640–652.

Margeirsson, S. (2008). *Processing forecast of cod – Decision making in the cod industry based on recording and analysis of value chain data*. Reykjavik, Iceland: Faculty of Engineering, University of Iceland.

Meuwissen, M. P. M., Velthuis, A. G. J., Hogeveen, H., & Huirne, R. B. M. (2003). Traceability and certification in meat supply chains. *Journal of Agribusiness, 21*(2), 167–181.

Moe, T. (1998). Perspectives on traceability in food manufacture. *Trends in Food Science & Technology, 9*(5), 211–214.

Moretti, V. M., Turchini, G. M., Bellagama, F., & Caprino, F. (2003). Traceability issues in fishery and aquaculture products. *Veterinary Research Communications, 27*, 497–505.

Mousavi, A., Sarhadi, M., Fawcett, S., Bowles, S., & York, M. (2005). Tracking and traceability solution using a novel material handling system. *Innovative Food Science & Emerging Technologies, 6*(1), 91–105.

Olsen, P. (2009). Food traceability process mapping. Standard method for analyzing material flow, information flow and information loss in food supply chains. In K. A.-M. Donnelly, & P. Olsen (Eds.), *Harmonizing methods for food traceability process mapping and cost/benefit calculations related to implementation of electronic traceability systems – Workshop hosted by Nofima association with the trace project 25–26th February 2009*. Tromsø, Norway: Nofima, ISBN 978-82-7251-679-5, Report 15/2009.

Olsen, P., & Aschan, M. (2010). Reference method for analyzing material flow, information flow and information loss in food supply chains. *Trends in Food Science & Technology, 21*(6), 313–320.

Olsen, P., & Borit, M. (2012). How to define traceability. *Trends in Food Science & Technology*, http://dx.doi.org/10.1016/j.tifs.2012.10.003.

Olson, T. K. (2005). *Potential changes in relative competitiveness in response to changes in the demand for traceability and assurance: A case study of Chilean salmon aquaculture*. Doctoral thesis. Logan, Utah: International Food and Agribusiness, Utah State University.

Olsson, A., & Skjöldebrand, C. (2008). Risk management and quality assurance through the food supply chain – case studies in the Swedish food industry. *The Open Food Science Journal, 2*, 49–56.

Opara, L. U. (2003). Traceability in agriculture and food supply chain: a review of basic concepts, technological implications and future prospects. *Food, Agriculture & Environment, 1*(1), 101–106.

Opara, L. U., & Mazaud, F. (2001). Food traceability from field to plate. *Outlook on Agriculture, 30*(4), 239–247.

Pálsson, P. G., Storøy, J., Frederiksen, M., & Olsen, P. (2000). *Traceability and electronic transmission of qualitative data of fish products*. Nordic Council of Ministers project nr. 66031400. Lyngby, Denmark: Danish Institute for Fisheries Research, Department of Seafood Research.

Peres, B., Barlet, N., Loiseau, G., & Montet, D. (2007). Review of the current methods of analytical traceability allowing determination of the origin of foodstuffs. *Food Control, 18*(3), 228–235.

Pèrez-Villarreal, B., Amàrita, F., Bald, C., Pardo, A., & Sagardia, I. (2008). Validation of traceability in the seafood production chain. In T. E. Børresen (Ed.), *Improving seafood products for the consumer, part VI seafood traceability to regain consumer confidence* (pp. 539–565). Cambridge, UK: Woodhead Publishing Limited.

Pouliot, S., & Sumner, D. A. (2008). Traceability, liability, and incentives for food safety and quality. *American Journal of Agricultural Economics, 90*, 15–27.

Randrup, M., Storøy, J., Lievonen, S., Margeirsson, S., Árnason, S. V., Ólavsstovu, D.Í., et al. (2008). Simulated recalls of fish products in five Nordic countries. *Food Control, 19*(11), 1064–1069.

Regattieri, A., Gamberi, M., & Manzini, R. (2007). Traceability of food products: general framework and experimental evidence. *Journal of Food Engineering, 81*(2), 347–356.

Riden, C. P., & Bollen, A. F. (2007). Agricultural supply system traceability, part II: implications of packhouse processing transformations. *Biosystems Engineering, 98*, 401–410.

Ringsberg, H., & Jönson, G. (2010). Perspectives of food supply chain traceability. In *Conference proceedings – The 12th World conference in transport research* (pp. 1–26). Lisbon, Portugal: World Conference on Transport Research Society (WCTRS).

Roheim, C., & Sutinen, J. G. (2006). *Trade and marketplace measures to promote sustainable fishing practices*. Issue paper No. 3. Paris, France: International Centre for Trade and Sustainable Development.

Ruiz-Garcia, L., Steinberger, G., & Rothmund, M. (2010). A model and prototype implementation for tracking and tracing agricultural batch products along the food chain. *Food Control, 21*(2), 112–121.

Sant'Ana, L. S., Ducatti, C., & Ramires, D. G. (2010). Seasonal variations in chemical composition and stable isotopes of farmed and wild Brazilian freshwater fish. *Food Chemistry, 122*(1), 74–77.

Schmid, A., & Connelly, J. (2009). *Round table on eco-labelling and certification in the fisheries sector – Proceedings*. 22–23rd April 2009. The Hague, The Netherlands: Agriculture, Nature and Food Quality, Organisation for Economic Co-operation and Development (OECD), and Food and Agriculture Organization (FAO).

Schröder, U. (2008). Challenges in the traceability of seafood. *Journal für Verbraucherschutz und Lebensmittelsicherheit, 3*(1), 45–48.
Schulz, L. L., & Tonsor, G. T. (2010). Cow-calf producer preferences for voluntary traceability systems. *Journal of Agricultural Economics, 61*(1), 138–162.
Schwagele, F. (2005). Traceability from a European perspective. *Meat Science, 71*(1), 164–173.
Sebestyen, G., Nedevschi, S., Saplacan, G., Cerghizan, M., Todor, N., & Rusu, M. (2008). Towards a traceability solution on the food supply chain. In *The 8th international conference on technical informatics (Conti' 2008)* (pp. 1–6). Timisoara, Romania: The Institute of Electrical and Electronics Engineers (IEEE).
Senneset, G., Forås, E., & Fremme, K. M. (2007). Challenges regarding implementation of electronic chain traceability. *British Food Journal, 109*, 805–818.
Senneset, G., Midtstraum, R., Forås, E., Vevle, G., & Mykland, I. H. (2010). Information models leveraging identification of returnable transport items. *British Food Journal, 112*(6–7), 592–607.
Skoglund, T., & Dejmek, P. (2007). Fuzzy traceability: a process simulation derived extension of the traceability concept in continuous food processing. *Food and Bioproducts Processing, 85*, 354–359.
Smith, G. C., Tatum, J. D., Belk, K. E., Scanga, J. A., Grandin, T., & Sofos, J. N. (2005). Traceability from a US perspective. *Meat Science, 71*, 174–193.
Souza-Monteiro, D. M., & Caswell, J. A. (2004). *The economics of implementing traceability in beef supply chains: Trends in major producing and trading countries*. Amherst, MA: University of Massachusetts. Department of Resource Economics, Working Paper No. 2004–6.
Sparling, D., Henson, S., Dessureault, S., & Herath, D. (2006). Costs and benefits of traceability in the Canadian dairy-processing sector. *Journal of Food Distribution Research, 37*(1), 154–160.
Spens, K. M., & Kovàcs, G. (2005). A content analysis of research approaches in logistics research. *International Journal of Physical Distribution & Logistics Management, 36*(5), 374–390.
Starbird, S. A., & Amanor-Boadu, V. (2006). Do inspection and traceability provide incentives for food safety? *Journal of Agricultural and Resource Economics, 31*(1), 14–26.
Storøy, J., Senneset, G., Forås, E., Olsen, P., Karlsen, K. M., & Frederiksen, M. (2008). Improving traceability in seafood production. In T. E. Børresen (Ed.), *Improving seafood products for the consumer, part VI seafood traceability to regain consumer confidence* (pp. 516–538). Cambridge, UK: Woodhead Publishing Limited.
Thakur, M., & Donnelly, K. A.-M. (2010). Modelling traceability information in soybean value chains. *Journal of Food Engineering, 99*(1), 98–105.
Thakur, M., & Hurburgh, C. R. (2009). Framework for implementing traceability system in the bulk grain supply chain. *Journal of Food Engineering, 95*(4), 617–626.
Thakur, M., Wang, L., & Hurburgh, C. R. (2010). A multi-objective optimization approach to balancing cost and traceability in bulk grain handling. *Journal of Food Engineering, 101*(2), 193–200.
Thompson, M. J. (2005). *Integrating traceability with onboard handling to enhance product quality and marketability of Eastern Pacific troll-caught albacore tuna (Thunnus alalunga)*. Master in science. Oregon State University.
Thompson, M., Sylvia, G., & Morrissey, M. T. (2005). Seafood traceability in the United States: current trends, system design, and potential applications. *Comprehensive Reviews in Food Science and Food Safety, 4*(1), 1–7.
Tracefood. (2012). *Tracefood wiki. EU-project 'TRACE'*. Available at http://www.tracefood.org/index.php/Main_Page Downloaded 01.04.12.
Turchini, G. M., Quinn, G. P., Jones, P. L., & Gooley, G. (2009). Traceability and discrimination among differently farmed fish: a case study on Australian Murray cod. *Journal of Agricultural and Food Chemistry, 57*(1), 274–281.
Van Rijswijk, W., Frewer, L. J., Menozzi, D., & Faioli, G. (2008). Consumer perceptions of traceability: a cross-national comparison of the associated benefits. *Food Quality and Preference, 19*(5), 452–464.
Viaene, J., & Verbeke, W. (1998). Traceability as a key instrument towards supply chain and quality management in the Belgian poultry meat chain. *Supply Chain Management, 3*(3), 139–141.
Voulodimos, A. S., Patrikakis, C. Z., Sideridis, A. B., Ntafis, V. A., & Xylouri, E. M. (2010). A complete farm management system based on animal identification using RFID technology. *Computers and Electronics in Agriculture, 70*(2), 380–388.
Wang, X., & Li, D. (2006). Value added on food traceability: a supply chain management approach. In *IEEE conference on service operations and logistics, and informatics (SOLI 2006)* (pp. 493–498). Shanghai, China: The Institute of Electrical and Electronics Engineers (IEEE).
Wang, X., Li, D., & O'Brien, C. (2009). Optimisation of traceability and operations planning: an integrated model for perishable food production. *International Journal of Production Research*, 1–22.
Zadernowski, M. R., Verbeke, W., Verhè, R., & Babuchowski, A. (2001). Towards meat traceability critical control point analysis in the Polish pork chain. *Journal of International Food & Agribusiness Marketing, 12*(4), 5–22.
Zhang, X., Zhang, J., Liu, F., Fu, Z., & Mu, W. (2010). Strengths and limitations on the operating mechanisms of traceability system in agro food, China. *Food Control, 21*(6), 825–829.