Identifying critical traceability points and elements of organisation and technology for the traceability system

The case of breeders and feed companies of the Dutch pork supply chain

Master thesis


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Acknowledgements

Following the horse meat scandal from 2013, I wondered how it was possible that nobody found out that processed food that was labelled as beef, could be substituted with horse meat. Especially because this is a violation of food safety, a subject that is increasingly important. This aroused my interest in the way data is arranged in a supply chain, whereby food safety plays an important role. This interest led to the subject of traceability.

The feed industry was not the first industry I considered, however as the study progressed, my interest in the feed industry grew. The feed companies that I invited for this research were almost all willing to join, what I really appreciated. It was a great learning experience to do the interviews with employees of large companies. I want to thank all of them who participated. Additionally, I want to thank Debbie Berghmans in particular, for showing me the factory of her company, which give me a great insight into the production process of feed and which was also fun to see. Furthermore, I want to thank all the other participants for their help, the time they took, and their willingness to share information which really helped me writing my thesis.

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Abstract

This research investigates the traceability systems within the feed companies and the breeders of the Dutch pork supply chain, as literature is lacking and incidents still occur within this sector. Traceability exists of four components: process, information, organisation, and technology. By identifying the Critical Traceable Points (CTPs): points where information loss may occur, traceability was investigated within the feed companies and breeders. The information and process flow were analysed to identify these CTPs. Moreover, elements of technology and organisation were analysed as well, as they determine how the processes are designed and what the information is collected, which direct influences the quality of the traceability systems.

For the empirical study, seventeen interviews were held with feed companies, a branch organisation of feed, a quality assurance company of feed, breeders, farmers, and experts. The questions were based on the four components of traceability to identify the CTPs and to examine whether the elements of technology and organisation of both actors meet the conditions for a traceability system.

In total, five CTPs were identified for the feed companies: two points of information loss were identified as codes and information were not shared, two points were identified as manual action took place which may cause information loss, and at one point, a transformation was not recorded. Analysis of organisation and technology elements showed that most of the elements met the conditions for a traceability system. There were two elements that did not meet the conditions: communication and linking data. Information about the materials and products are not shared within the chain and technology for linking systems is lacking. As the pressure for sharing information in the chain increases, the level of organisation and technology should be improved in order to share information with the suppliers and farmers.

The breeders do not have traceability systems, so the CTPs could not be identified for them. However, a lot of data is already saved and the breeding is based on high quality standards, making traceability possible.

Keywords: traceability, breeders, feed companies, critical traceability points, Dutch pork chain

Executive summary

In recent decades, there have been a large amount of food scandals affecting the consumer's confidence. As a result, there was a clear need for a traceability system within the supply chain and governmental regulations have been introduced to ensure food safety. However, the horse meat scandal from 2013, where horse meat labelled as beef was found, showed gaps in the current traceability systems. Traceability is the collecting, documenting, maintaining, and applying of information related to supply-chain processes, which aims to deliver guarantees to consumers and stakeholders on the origin, location, and history of a product.

An industry that is involved in a number of food incidents is the feed industry. The feed industry has some characteristics that affect the precision of traceability systems such as: formulation of feed changes frequently, feed comes from all around the world, and it is difficult to distinct raw materials batches. The main focus of this research is on the pork feed industry, as it is challenging for them to have a good working traceability system. Additionally, the focus of this report is also on the breeders of the pork chain, as studies involving traceability of the breeders are lacking.

According to the literature, a traceability system exists of four components: process, information, technology, and organisation. The process includes the production process and the flows of material and product along the chain. For each process step, information needs to be documented. The process and information flow together constitute the traceability model. Within the component organisation, all the required arrangements for obtaining traceability are found, both for the chain and for the company itself. The last component, technology, is needed for product identification, information sharing, data capturing, analysis, and storage. The components process flow and information flow are affected by the arrangements made in the organisation and the available technology.

A suitable method for investigating traceability systems is: the identification of Critical Traceability Points (CTPs). A CTP is "a point where information loss may occur due to possible loss of identification and flaws in registering transformations". These CTPs have already been identified for the farmers and slaughterhouses of the Dutch pork supply chain, but not yet for the breeders and feed companies. The first two components of traceability, process and information, should be analysed to identify the CTPs within a supply chain. Previous research that investigated CTPs found that the bottlenecks of traceability systems were a lack of unique identification of traceable units and a lack of transformation recording. Therefore, special attention is paid to the recording of transformations and the unique identification of traceable units while analysing the process flow and information flow in this study. Unique identification means the recording of a batch, which is a quantity of a homogeneous subset of products with similar characteristics and the same history. Transformations are points in the production process where resources are added, split up, mixed, or transferred. These points need to be recorded, otherwise information about the materials is lost.

It is also important to analyse the technology and organisation, as they influence the process and information flow. Organisation and technology both have different elements that are important for a traceability system. These elements of technology and organisation are analysed to examine whether these elements met the conditions for a traceability system.

These two researches together formed the objective of this study: to identify the Critical Traceability Points (CTPs) for the feed companies and breeders within the Dutch pork supply chain, and to examine whether the elements of technology and organisation of both actors meet the conditions for a traceability system.

The first part of the literature study provided general information about the process and information flow of traceability. Additionally, information was obtained about the process and information flow of the feed companies. The production of compound pig feed starts with receiving the raw materials where after the raw materials are processed; this can be done by grinding, mixing, pressing, crumbling, or sieving the materials into compound pig feed. At each step, different information should be recorded, such as the type and quantities of raw materials that are used and when a batch is delivered.

The second part of the literature study provided information about the different elements of technology and organisation. The technology needed for traceability systems exists of several elements. The first one is identification, which is necessary to conduct information from materials and processes. The second element is registration and administration, this is where the information is processed and stored. An example of this is an ERP (Enterprise Resource Planning) system. The last element is linking data, which is needed for sharing information within the chain. The elements of organisation are based on two proven theories: the managerial elements of quality control and the supply chain partnership. Managerial elements of quality control are adapted to managerial elements of a traceability system: quality design, quality control, traceability design, traceability control, traceability improvement, and traceability policy. The elements of supply chain partnership are trust, commitment, and communication.

For obtaining data, seventeen semi-structured interviews were held with feed companies, a branch organisation of feed, a quality assurance company of feed, breeders, farmers, and experts. The interview guides were divided into four main parts: process flow, information flow, organisation, and technology. The process and information questions were based on the information obtained from the literature and were used for identifying the CTPs, with special attention to the batches and the transformations. The technology and organisation questions were based on the elements obtained in the literature study and were used to examine whether the elements of technology and organisation met the conditions for a traceability system.

Analysis of the process flow showed that the feed companies work with many materials and that many transformation occur during the production process. Despite these difficulties, the traceability systems in the feed companies are of a high level, in which all the materials were uniquely identified and all the transformations that occurred within the feed companies were almost always automatically recorded. In total, five CTPs where information may get lost have been identified for the feed industry. The first CTPs occurred between the supplier and the feed industry since the supplier does not deliver codes or information about the materials, causing information loss. Also, the weighing of small materials and joining of the small materials is often done manually, which can cause mistakes and information loss (CTP 2 & 3). There is also no sharing of information about the history of the feed between the feed companies and the farmers (CTP 4). Lastly, transformation in the silos of the farmers are not recorded, causing CTP 5.

Analysing the elements of technology and organisation showed that most of the elements meet the conditions for a traceability system. The elements of technology and organisation are sufficient for having a traceability system within the feed companies. However, elements important for a chain traceability system, such as communication and linking data, did not meet the conditions for a traceability system. Companies active in the feed industry are cautious in sharing information in the chain. Besides, systems linking the data and standardisation of the data within the feed industry was lacking. In order to improve these elements and the CTPs, a few changes have to be made. Requirements at the organisation level should include that manual action should be reduced as much as possible, whereby available technology should be adapted or implemented to make this possible. The communication within the feed industry should be improved in order to share information and to increase the amount of standardised data within the chain. The focus should be on the element communication in order to decrease distrust and to enhance the sharing of information. Additionally, systems for sharing data should be implemented. Blockchain might be a useful technology for this in the future. It is important that these suggested improvements are taken seriously by the actors in the feed industry, as the pressure for sharing information within the feed industry will increase.

This study also investigated traceability within the breeders. The CTPs are not identified for the breeders, as they do not have traceability systems yet. However, a lot of data is already saved and the breeding is based on high quality standards, making traceability possible.

List of abbreviations

CBL	Centraal Bureau Levensmiddelenhandel
CTP	Critical Traceability Point
EDI	Electronic Data Interchange
ERP	Enterprise Resource Planning
GMO	Genetically Modified Organism
GMP	Good Manufacturing Practice
ISO	International Organization for Standardization
IT	Information Technology
MES	Manufacturing Execution System
NIR	Near-Infrared Spectroscopy
NVWA	Nederlandse Voedsel- en Warenautoriteit
RFID	Radio Frequency Identification
RVO	Rijksdienst voor Ondernemend Nederland
SCADA	Supervisory Control and Data Acquisition
XML	Extensible Markup Language

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1. Introduction

1.1 Introduction

In recent decades, the number of meat scandals has increased, such as Bovine Spongiform Encephalopathy, dioxin in pork and chicken feed, and classical swine fever (Aung & Chang, 2014; Heres, Hoogenboom, Herbes, Traag, & Urlings, 2010; Viktoria Rampl, Eberhardt, Schütte, & Kenning, 2012). These incidents affected the consumer confidence in the meat industry, which resulted in reduced purchase of meat (Barnett et al., 2016). As a result, there is a need to enable traceability in the meat supply chain (K. A. Donnelly, Karlsen, & Olsen, 2009). Traceability is the collecting, documenting, maintaining, and applying of information related to supply-chain processes, which aims to deliver guarantees to consumers and stakeholders on the origin, location, and history of a product (Opara, 2003).

Governmental regulations have been introduced to ensure food safety and to improve consumer confidence (Trienekens & Zuurbier, 2008). However, in the beginning of 2013, the Food Safety Authority of Ireland discovered that major retailers in the United Kingdom and the Republic of Ireland had sold processed food products which were labelled as beef, but which were partly or fully substituted with horse meat (Sarpong, 2014). The horse meat scandal revealed that there are still gaps in the current traceability systems within the meat supply chain.

The Dutch pork supply chain

The animal feed industry is involved in a number of food incidents. In 1999, 50 kg of polychlorinated biphenyls was accidentally added to the production of 500 tonnes feed for poultry and pigs in Belgium, which resulted in a major food crisis (Covaci et al., 2008). Another incident happened in 2008, where high levels of dioxins were discovered in pork meat in the Netherlands and France. This was caused by animal feed in the Republic of Ireland (Heres et al., 2010). Such incidents show the importance of identifying the used resources present in feed, as the raw materials used as ingredients influence the safety and quality of the final products (Morcia, Tumino, Ghizzoni, & Terzi, 2016). For that reason, the European Union has mandated traceability in the food supply chain, including animal feed. However, according to Hoorfar et al. (2011), some challenges occur in feed traceability. Firstly, the formulation of feed changes frequently. Secondly, feed contains raw materials from all around the world. Especially soybean, palm kernel meals, and cereals are imported many times, as these materials are essential for European feed. Lastly, it is difficult to make a clear distinction between raw material batches due to the many cross points during import, production, storage, and transport (Hoorfar et al., 2011). According to Trienekens and Zuurbier (2008), this results in the fact that not all feed ingredients can be fully traced backed.

Upwards in the Dutch pork supply chain, the main actors are the animal feed companies and the breeders, on whom the focus lies in this report. As described above, traceability within the feed industry is challenging. Besides, studies involving the traceability systems of the breeders are lacking. This makes it interesting to investigate these two specific actors. Additionally, this research is a valuable addition to the study of Denolf (2014), who already investigated the traceability systems of the farmers and slaughterhouses of the Dutch pork supply chain. An overview of the study area of this research is shown in Figure 1.

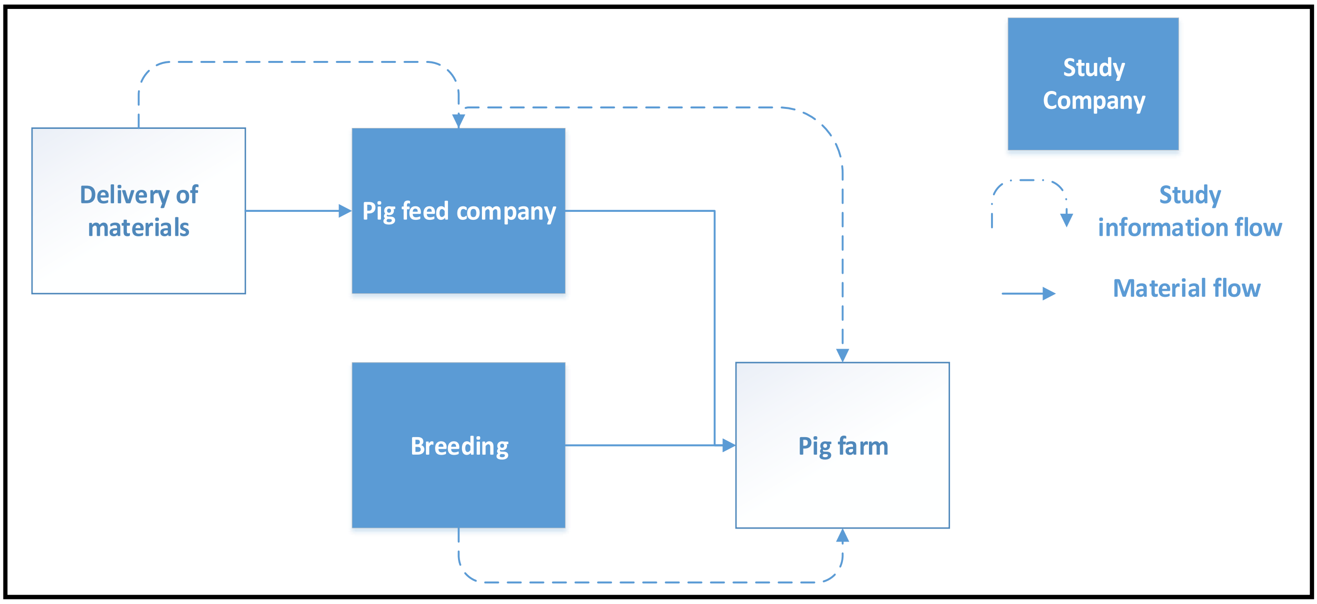

Figure 1. Study area of the Dutch pork supply chain

Breeding of pigs takes place at the very beginning of the pork production chain and is almost always done through artificial insemination. The most important breeding organisations in the Netherlands are Topigs Norsvin, Pic, Danbred and Hypor (Dierenaangelegenheden, 2010). After the pigs are born, they need feed. In the Netherlands, there are about 100 animal feed companies, of which the three major companies are: Agrifirm, ForFarmers and De Heus Voeders (Bron, 2016).

The four components of traceability

According to Verdenius (2007), a traceability system consists of four components: process, information, organisation, and technology.

1. Process: The process includes the production process and the flows of material and product along the chain. As the processes have been designed for aiming efficiency and cost reduction and not for traceability, many processes have problems with detailed traceability.

2. Information: For each process step, information needs to be documented to ensure that information about the history of the product and the related process information can be traced back.

The process design and the collecting of information together constitute the traceability model (Verdenius, 2007).

3. Organisation: The organisation includes all the required arrangements for obtaining traceability, both for the chain and for the company itself. It states who is responsible for the product and information handling, what the definition of traceability information is, how information is exchanged in the chain, and what the traceability goals are (Verdenius, 2007).
4. Technology: A traceability system also requires advanced technology, which is needed for product identification, information sharing, data capturing, analysis, and storage (Opara, 2003).

The process design and the collecting of information are determined by the arrangements made in the organisation and the available technology (Verdenius, 2007).

Identification of Critical Traceability Points

According to Denolf (2014), a suitable method for investigating traceability systems within a chain is: the identification of Critical Traceability Points (CTPs). A CTP is a point where systematic information loss occurs, which means that information about a product or process is not linked to this product and recorded systematically (Karlsen, Donnelly, & Olsen, 2011). Critical Traceability Points have been identified for the farmers and slaughterhouses of the Dutch pork supply chain by Denolf (2014), but not for the breeders and feed industry. In order to identify the CTPs, the process flow and information flow of the supply chain should be analysed, as these two components constitute the traceability model (Karlsen et al., 2011).

Several studies which investigated CTPs in the food supply chains have reported that there is a lack of unique identification of traceable units and a lack of transformation recording (K. A. Donnelly et al., 2009; K. Karlsen, Sørensen, Forås, & Olsen, 2011; Olsen & Aschan, 2010). A traceable unit is usually a batch, which is a quantity that is going through the same processes. A traceable unit should be uniquely identified throughout the supply chain to keep information available for other actors (Aung & Chang, 2014; Denolf, 2014). Transformations are points in the production process where resources are added, split up, mixed, or transferred, as shown in Table 1 on the next page (K. A. Donnelly et al., 2009). Transformations are seen as the factor that influences the precision of a traceability system as the transformation of resources during the production process makes it challenging to have a complete and continuous recording of information (Karlsen, Olsen, & Donnelly, 2010). While analysing the process flow and information flow, special attention must be paid to the recording of transformations and the unique identification of traceable units.

Table 1. Transformation of resources (K. A. Donnelly et al., 2009)

Transformation	Relationship	Definition
Joining of resources	Many to one	Joining together of different units of a main resource
Transfer of resource	One to one	Transferal of a resource without it being split up or mixed
Addition of resource	Many to one	One main resource being mixed with other resources in lesser quantities
Splitting of resource	One to many	A resource being split up into multiple units

In this research, the adapted CTP definition of Denolf (2014) is used, where CTPs are defined as "points where information loss *may* occur due to *possible* loss of identification and flaws in registering transformations". According to Denolf (2014), this definition provides a more complete picture of the traceability problems that occur within an industry.

In addition to identifying the CTPs for the breeders and feed companies, it is also imported to analyse the present technology and the organisation of the breeders and feed companies. These two components determine how the processes are designed and what the information is collected, which direct influences the quality of the traceability systems (Aung & Chang, 2014; Verdenius, 2007). Organisation and technology have both different elements that are important for a traceability system. These elements of technology and organisation will be analysed to examine whether these elements meet the conditions for a traceability system. The elements of organisation and technology will be provided in the literature review.

1.2 Problem statement

There is increasing interest in the traceability of the pork supply chain. Though, literature about traceability at the beginning of the pork supply chain is limited. Denolf (2014) identified the CTPs for the farmers and slaughterhouses within the Dutch pork supply chain, but not for the breeders and feed companies. However, incidents are still occurring at the feed companies and studies about traceability within the breeders are scarce. This makes it interesting to specifically investigate these two actors of the pork supply chain.

This research can be divided into two main subjects. The first subject is the identification of the CTPs, for which the first two components of traceability, process and information, should be analysed. The second subject is the analysis of the other two components of traceability, organisation and technology, in order to examine if their elements meet the conditions for a traceability system.

1.3 Objectives

The objectives are to identify the critical traceability points for the feed companies and breeders within the Dutch pork supply chain, and to examine whether the elements of technology and organisation of both actors meet the conditions for a traceability system.

1.4 Research Question

What are the critical traceability points for the feed companies and breeders within the Dutch pork supply chain, and do the elements of technology and organisation of both actors meet the conditions for a traceability system?

1.5 Sub-Questions

1. What does the production process of the breeders and feed companies look like?
2. What information about the production process is recorded and shared between the suppliers, feed companies/breeders, and farmers?
3. Which elements of technology meet the conditions for a traceability system of the breeders and feed companies and which elements do not?
4. Which elements of organisation meet the conditions for a traceability system of the breeders and feed companies and which elements do not?

Sub-questions 1 and 2 will be used for identifying the CTPs, where special attention will be paid to transformations and unique identification of traceable units. Sub-questions 3 and 4 will be used for analysing the elements of organisation and technology of the breeders and feed companies to know which elements do not meet the conditions for a traceability systems. The results of the sub-questions will be used to make recommendations for the traceability system of the feed companies and the breeders.

1.6 Research framework

The research framework describes the steps that have been taken during this research to achieve its objective. First, a literature review was conducted and secondary data was obtained. Specifically, literature was searched concerning the process and information flow of traceability, the elements of technology and organisation needed for traceability, and the process and information flow of the Dutch feed companies.

Secondly, an empirical research has been conducted with stakeholders of breeders and feed companies. Interviews were held with feed companies, a branch organisation of feed, a quality assurance company of feed, experts, farmers, and breeders. This interviewees provided information about the process and information flow of the breeders and feed companies and about the elements of organisation and technology.

In the next step, the process and information flow has been analysed to identify the CTPs for the breeders and feed companies. Additionally, analyses of the organisation and technology elements were performed to determine if these elements met the conditions of a traceability system. An overview of the research framework can be found in Figure 2.

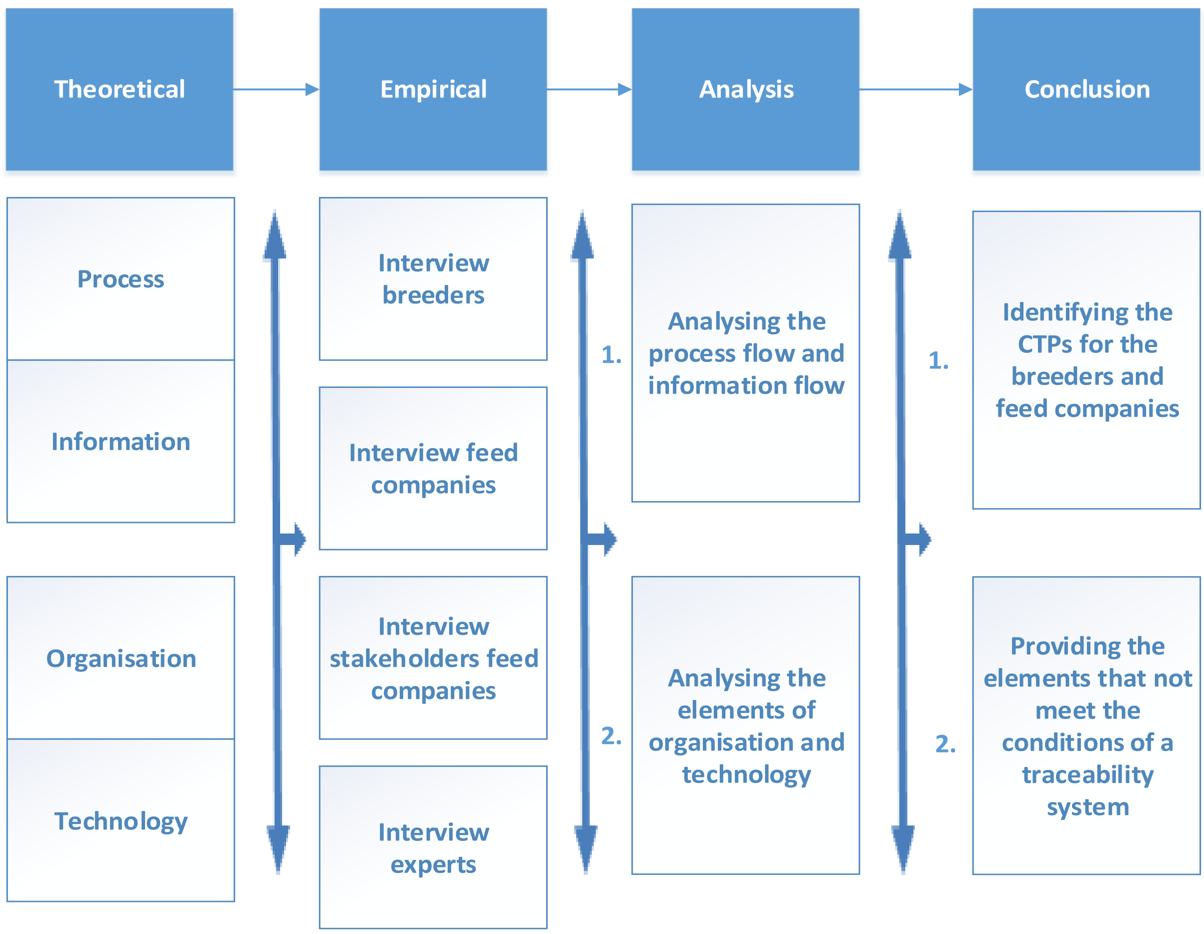

Figure 2. Research framework

2. Literature review

In this chapter, first the different actors at the beginning of the Dutch pork supply chain are described, whereafter the characteristics of a traceability system in the food industry follow. Then, a literature study is conducted to gather information on the process and information flow of traceability. Next, the organisation and technology elements of a traceability systems will be introduced.

2.1 The different actors at the beginning of the Dutch pork supply chain

In most of the pork supply chains, the production stages are performed by different chain actors. These stages are: breeding – farming– slaughtering – processing – retail – and consumption. The feed companies are input providers for the pork chain, hence they are extremely important for the pork chain as feed is a major cost component of the pork production (Trienekens & Wognum, 2009). As this research investigates the breeders and feed companies, they will be described in more detail.

Breeding companies

Breeding companies produce semen, sows and boars for pig farms. They perform research to genetics in order to improve genetics and cultivation of pig species (Trienekens & Zuurbier, 2008). The activities of breeders are the production of breeding gilts and boards, but also include artificial insemination (Hoste, Bondt, & Ingenbleek, 2004). Breeding is an activity that is increasingly taken place on a global scale, where just a few companies control the breeding market (Gura, 2008). The largest breeding companies that are active in the Netherlands are Topigs Norsvin, Hypor, PIC and DanBred. Topigs Norsvin has the largest market share in the Netherlands with 85,5% in sows and 70% in bears (Klein Swormink, 2011).

Feed companies

The feed industry is of great importance for the pork chain, as feed is among the major costs of the pork production (Trienekens & Zuurbier, 2008). The feed for pigs in the Netherlands mainly consists of compound feed and moist by-products. The feed companies are involved in the production and sales of compound feed for the pigs (Perez, de Castro, & Furnols, 2009).

As mentioned before, the three major feed companies on the Dutch market are Agrifirm, ForFarmers, and De Heus Voeders, which account for 63% of the Dutch market. All three of them have a turnover of more than 2 billion and belong to the 20 largest producers worldwide (Verbeek, 2015). In total, there are about 100 feed companies active on the Dutch market, of which 80 produce compound feed (FEFAC, 2016). An overview of the largest compound feed producers that are active on the Dutch market is shown in Figure 3 on the next page.

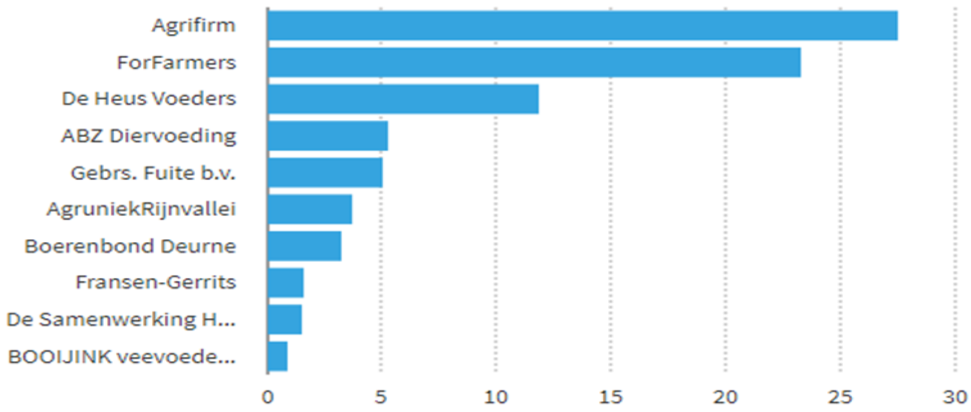

Figure 3. The largest feed companies on the Dutch market including their market share (Bron, 2016).

Recent years, the Dutch feed market has been characterized by mergers and acquisitions. This is the result of a decreasing market, caused by the decline of the pig population. Through mergers and acquisitions, the operating costs are reduced, what also resulted in a decrease of produced compound feed (Bron, 2016; Verbeek, 2015). The total amount of produced pig compound feed was 5132Kton in 2016, while it was 5936kton in 2009 (FEFAC, 2016).

For the production of compound feed, the Dutch feed companies together use more than 300 different types of raw materials. The origin of these feed materials is widely spread across the world, as shown in Figure 4 (Nevendi, 2016). The feed companies use products and co-products from agriculture and food processing industries. Pig feed requires energy sources, protein sources, minerals, vitamins, and water as basic nutrients. Almost all the materials that add energy to the feed are from the Netherlands and Europa. However, the materials that provide the protein in feed are coming from all over the world (Nevendi, 2016). In total, 4400kton protein materials were used for compound feed in 2015, of which 54% was of origin outside Europe (Cormont & van Krimpen, 2016).

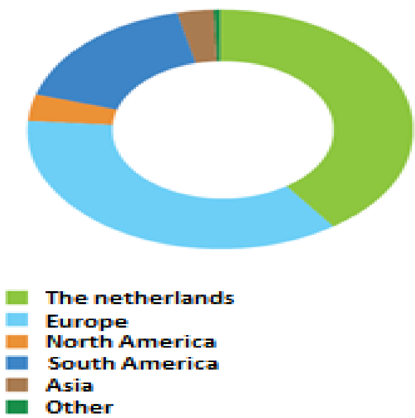

Figure 4. Origin of Dutch animal feed materials (Nevendi, 2016)

Almost one third of the protein materials used for compound feed consists of soy products (1800kton). Soybean is popular as ingredient in compound feed because animals grow quickly when using this protein. Soy products for compound feed produced in the Netherlands are imported from Brazil (55%), Argentina (40%) and the United States (5%) (Balkema, 2014). The animal feed sector is by far the most important soy processor sector in the Netherlands (Nederlandse-sojacoalitie, 2014). Sunflower meal is another material that provides protein and is imported from different countries. In 2015, 745kton was used for producing compound feed and this was imported from Ukraine, China, and Argentina. Rapeseed is also an important material for producing compound feed and is imported from Germany (511kton) and France (128kton). Palm kernel flake also adds protein to the feed and is an essential material for compound feed. In 2015, all of the 879kton palm kernel flake material was imported from outside Europe. In 2013, the largest part of the palm kernel flake was imported from Malaysia (75%), the other 25% was imported from Indonesia (Balkema, 2014; Cormont & van Krimpen, 2016). There is no information available on the composition of compound feed per animal category as this information is confidential knowledge of the feed companies (Kleter et al., 2017).

2.2 Food Traceability

Food traceability is the collecting, documenting, maintaining, and applying of information related to supply-chain processes aiming to deliver guarantees to consumers and stakeholders on origin, location and history of a product, and assisting when food safety problems occur (Opara, 2003). Bosona and Gebresenbet (2013) added to this definition that a traceability system ensures that the product can be checked for safety and quality control and can be traced upwards and tracked downwards at any time required.

The main difference between a food supply chain and other supply chains is that in the food supply chain continuous changes in the quality of the product take place, from the grower till the consumer. Problems with food safety may occur at every point of the supply chain. Because of this, food safety is a responsibility for the entire supply chain and all of the actors involved (Apaiah, Hendrix, Meerdink, & Linnemann, 2005).

One important issue for a food traceability system in the entire chain is the lack of standardisation. Standardisation is the exchange of information in a standardized format between various actors in the chain and is important for an efficient supply chain traceability system. However, companies in the food chain have their own standardisation which can cause problems when data has to be exchanged from one actor to another (Bosona & Gebresenbet, 2013). There is an increasing need for the industry to use standards so that different software systems can communicate with each other (Anne-Marie Donnelly, Mari Karlsen, & Dreyer, 2012). A way to deal with this is standardised data terminology for the entire sector, such as structured data lists, vocabularies, and ontology (Thakur & Donnelly, 2010).

Another important problem in the food industry is the concern about data security since it can be sensitive information that needs to be exchanged. Companies do not want to share the data, unless the data is stored in protected repositories (Forås, Thakur, Solem, & Svarva, 2015).

2.3 The process and information flow of a traceability system

As mentioned before, the process flow and information flow together constitute the traceability model (Verdenius, 2006). The process and information flow of a traceability system are explained based on Tielemans (2004), since he described this in detail and applied it to the food industry. Subsequently the process and information flow of the feed companies will be discussed.

2.3.1 The process flow

A batch forms the basis of a traceability system. A batch is a quantity of a homogeneous subset of products with similar characteristics and the same history. Defining a batch determines which part of a stock is considered as an equivalent whole. It can be necessary to define several different batches through differences in product and process characteristics. Raw materials of agricultural origin can have strong fluctuations in quality and the same applies to processed products. These differences result in the definition of new batches where the products within a batch again have the same characteristics. Besides the need of the same product characteristics, a batch also needs the same process history. This means that the entire batch has gone through the same storage, processing, and transport process. It may happen that there has been an incident during one of these processes that influences the end product. If, for example, a batch of fish is caught in one catch, but the batch of fish is delivered with different transports, each transport should be seen as a new batch as the transport history is different. This is important because the temperature during one transport can be too high, which affects the end product.

It is complicated to collect information of a batch in the food industry due to the many transformations during processing and storage. Besides, the physical structure of storage locations and the production device are not designed to keep the different batches separated. An example is when a new delivery of liquid ingredients is deposited in a silo. Without additional action, the administration shows separate batches present in the silo. However, physically the batches are joined inside the silo.

Batch-mix production and semi-process production

In order to further explain the collection of information about a batch, it is important to understand how the production process in the food industry works. The production process in the food industry almost always exists of two parts with each having specific characteristics: one or more production processes and the packing process (Tielemans, 2004), as shown in Figure 5 on the next page.

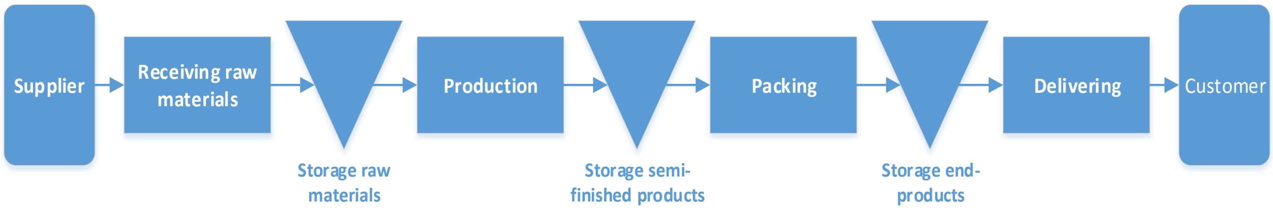

Figure 5. The flow of goods in a food processing organisation (Tielemans, 2004).

There are two kinds of production processes in the food industry: a batch-mix production and a semi-process production. A batch-mix production is a production process at which batch formation takes place. A product that arises from a batch-mix production is completely homogeneous: it has identical characteristics and exactly the same process history. This causes that all the products that arise from one production process, are considered as one batch.

When there is a semi-process production, different products are made in different production runs. There is a continuous process during which raw materials are added continuously. No batch formation is taking place in this production process. The output of one production process cannot be considered as a homogeneous batch, because the production and process characteristics constantly change during the production process. By taking samples during the packing process, the final characteristics of the batch are determined.

However, it can happen that the packing process is physically connected to the production process, without interim storage. The characteristics of the first packed end products can differ from the last one. Despite the fact that no natural batch formation takes place, a choice will have to be made for the definition of a batch. An estimate has to be made how many end products can be considered as one batch. This can be done by fixed time intervals (one hour or one day) or by logistics units (one pallet as one batch).

A definition of a batch based on time intervals is common, because it is an easy method. The production date is mostly used as batch identification. However, it is well known that such a defined batch is not a true homogeneous unit. This is why multiple inspections on the batch take place during one production run.

The definition based on logistic units has two basic forms: all the products that arise from one production process as a batch or one pallet as a batch. If all the products that arise from one production process are defined as a batch, this batch is also not a true homogeneous unit. Again, multiple inspections take place during one production. If one pallet is defined as one batch, the quantity of the batch is low, so fewer inspections per batch will take place. The disadvantage of this method is that one production process leads to several batches (Tielemans, 2004).

Transformations

As already told, the food supply chain has to deal with transformations of resources during storage and production process. Resources are added, split up, mixed or transferred and these transformations influence the precision of a traceability system. Joining of resources can be done consciously or unintentionally. Conscious joining happens when it is intended to make one batch of two batches. In other cases, an unintentional joining of resources occurs. An example is a new delivery of a liquid ingredient which is joined to a silo with a remaining stock. The two batches are mixed in the silo, while these batches are administratively separated. This should be avoided as much as possible. It leads to confusion and mistakes, especially in situations where there is time pressure as with a recall. To maintain a workable situation, an acceptable level of mixing should be defined. This determines if it is acceptable to have a small mixing of batches without a separate administration.

When a product does not meet the requirements, the entire batch has to be removed as the batch is seen as a homogeneous unit with the same characteristics. A recall of this batch will follow. However, the cause is probably somewhere else, upstream the chain. When the cause is found, tracing forward will determine which end product batches are also affected. It is possible that the raw material, that caused the deviation, is split in several end products. This would lead to the suspicion of multiple batches due to the transformations. The total amount of suspected end products is many times larger than when one batch of raw materials is processed into one batch of end products. This is the most accurate way of traceability, while transformations lead to a smaller degree of accuracy. Figure 6 shows that joining or splitting of resources leads to several suspicious batches when one batch is contaminated (Tielemans, 2004).

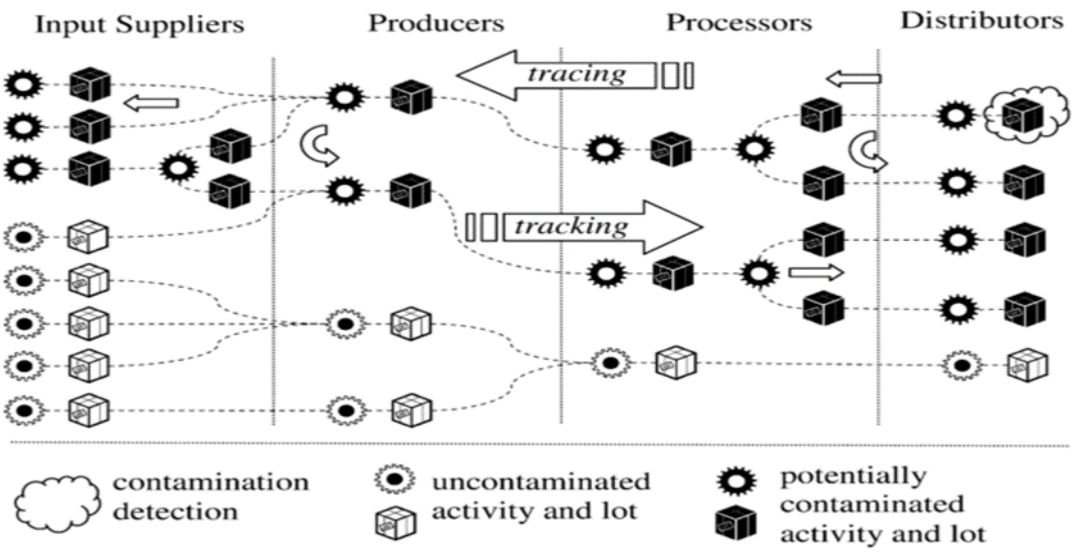

Figure 6. Transformations leads to several suspicious batches (lot=batch) (Bechini, Cimino, Marcelloni, & Tomasi, 2008)

2.3.2 The information flow

A traceability system sets requirements for the process flow in the chain and the collecting of information of this process flow. In this section, the primary process steps are described, including the information that needs to be documented.

Receiving goods

First, it needs to be determined which incoming products need a batch number. As traceability is required for all the products that are processed, it seems logical that every incoming product needs a batch administration. In many cases the supplier will already have his own batch number. With packed products, this number can be found on the package, pallet or shipping document. It is possible that the batch number of the supplier is not unique in the company's own administration or that the supplier and the company do not have the same batch number (lack of standardisation). A new batch number will then be defined and this number has to be applied to the package for physically recognition. For a product without a package, is it not possible to have a physical identification of the batch number. The storage location will then serve as the physical identification. The internal batch number, the suppliers batch number, and the storage location should be linked in the administration. Extra information about the batch should be added to the administration, such as the time of delivery, information about the supplier, and information about the delivered batch.

Storage

Especially the storage of bulk products needs special attention with regard to traceability. Bulk products are mostly stored in a silo or tank. The storage capacity is in most cases limited, which results in the storage of different batches in one silo. Through the joining of batches, it is difficult to conduct a batch administration system for materials in bulk storage. There is a possibility that the real, physical situation differs from the administrational situation. Four different situations can occur during the storage of bulk materials:

1. The first situations is the storage of one batch per silo. When the silo is empty, it is cleaned before a new batch will enter the silo. The batches will not join with each other, which results in an easy batch administration.
2. In the second situation there is again one batch per silo, only this time the silo is not cleaned when the silo is empty. This results in a small joining of the new batch in the silo with some leftovers of the old batch. A choice has to be made whether a small joining between the two batches is acceptable.

3. In the third situation, the batches are joined into the silo, before the silo is empty. The batches will mix in the silo. A choice has to be made whether a new batch is defined as a joined batch. When the silo is cleaned periodically, this is optional.
4. In the last situation, the batches are joined to the silo, without a periodic cleaning. The percentage of the older batches decreases, but a complete absence cannot be guaranteed. It is not desirable to define a joined batch in this situation, as it creates a hierarchy of batches that goes back to the start of the creation of the batch administration. A method based on the time of joining batches into the silo fits better in this situation.

Information that should be collected during the storage of batches in the silo includes the storage location, the time the batches are added into the silo, and the time the storage location is reported empty.

Production

In the production process, different raw materials are processed and packed into end products. Transformation occurs frequently in the production process. For each raw material that will be processed, a choice must be made for a method of recording the use of raw materials. Each method influences the precision of traceability. There are four basic methods for this:

1. The recording of actual use of raw materials. The exact amount of raw material used for production is measured per batch. This method is the most accurate way for a traceability system. However, disadvantages are that measurement equipment is necessary for the measurement and administration of the used raw material, and that the administration burden of this method is high.
2. The recoding based on time intervals. In some situations, it can be difficult to link the use of raw materials to the production process. Transformations make it difficult to determine which exact batch was used, or the required measurement equipment to break down the use of raw materials per production run is not available. In this method, the recoding of raw materials is based on a time interval and linked to the production run.
3. The recoding based on normative usage. In this method, the stock is normative debited, based on the pre-estimated use. When the end product is finished, the use of the raw material is directly debited. This method is usually not suitable for raw materials with a batch number, because there is no guarantee that the raw material batch that is normative debited in the administration, is the same raw material batch that has actually been used.
4. The recording based on stock usage. With the use of cheap raw materials, the costs are taken immediately upon receipt. There is no administrative stock available. By controlling the physical

stock periodically, the stock can be replenished. The receipt time of the materials will be used for linking the raw materials with the end products.

Using the right method depends on different aspects. If traceability is important because of a high risk for the raw materials to have a deviation or when the raw materials determine a large part of the cost price, the exact use of raw materials is important to record.
During the production process, information that should be recorded includes the production date, the amount of raw materials used, and the machine that is used (Tielemans, 2004).

Delivering

Delivering the end product from the factory to the farmer is important, as problems regarding food safety can still occur. For example, the temperature can be too high in a truck, affecting the food safety. Hence, it is important that information is also recorded during transport and delivery. Examples of information that should be recorded: delivery number, the weight that is delivered, and information about the farmer.

2.3.3 The process and information flow in the pig feed industry

The European union has mandated that feed must be traceable from the source of production to the retailers, as stated in the General Food Law. The feed companies have to record where and from whom the feed materials were received, who the purchaser of the feed is, and information regarding transport and storage of products. These records are required to save for five years and should include the address of the supplier, type of material, amount, and the production dates (Kleter et al., 2017).
To identify the CTPs for the pig feed companies, insight into the process and information flows is required. The production of compound pig feed starts with receiving the raw materials where after the raw materials are processed; this can be done by grinding, mixing, pressing, crumbling, or sieving the materials into compound pig feed. An overview of the production steps is shown in Figure 7, including the transformations that take place in the production process (Binter et al., 2011; PDV, 2002).
The materials that are used by European feed companies come from European and overseas producers and are commonly traded as bulk. A batch of material generally is a mix of several batches, already at the production site. Besides, if transportation includes loading and unloading events, joining and splitting of material occurs, what makes it hard to identify the origin of the batch (Binter et al., 2011).

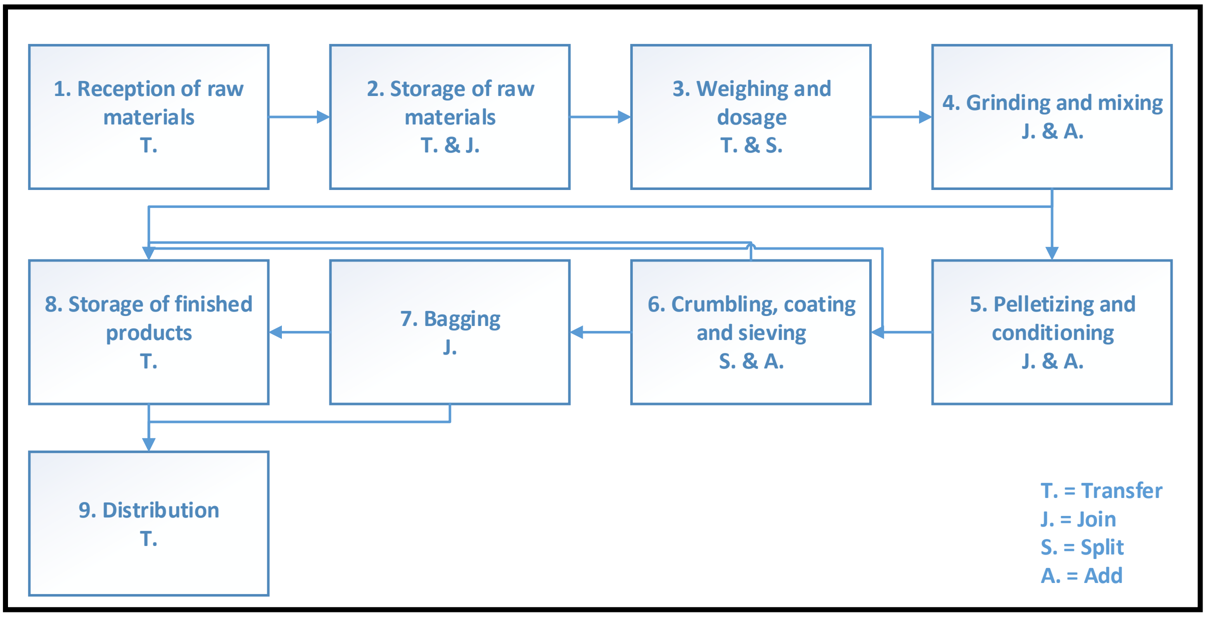

Figure 7. Process flow at the feed company

The information collection per process step necessary for the traceability system of feed companies is described below based on Product Board Animal Feed (PDV, 2002), who investigated the traceability of the Dutch compound feed industry in 2002 (Table 2). The first process step is the receiving of raw materials. The raw materials are transferred from the suppliers towards the feed company. Every incoming batch of raw materials is recorded in the administration with an internal batch number, which ensures the uniqueness of the batch within the company. The data should be linked to the internal batch number of the raw materials and recorded in the administration for incoming goods. Additionally, information about the type and quantities of the raw materials, time of delivery, delivery date, the name and address of the supplier, the name and address of the carrier and the method of transport needs to be administrated when receiving the raw materials.

The second process step is the storage of raw materials. It is important that all the silos and other fixed storage locations have a unique code in order to make a record of which batch of materials is in which storage location. A storage location needs to be reported empty each time a storage location is empty. Additionally, a record is kept of the sequences of the raw materials in the storage locations to prevent contamination.

The production process starts physically with the weighing and dosage process. The raw materials are transferred and split in this process step. The production of feed starts here and is recorded in the administration through the allocation of the article number of feed combined with the production date. By this unique combination number, the product can be followed during the entire production process. When the raw materials come out of the storage, they are weighed and dosed and this data is linked to the combination of article number and production date.

Process step 4, 5, 6 and 7 are administratively recorded in the same way. Each production line for the production of compound feed is provided with a unique code. This unique code of the used production line is linked to the article number and the production date. In step 4 and 5, raw materials are joined and added while in step 6 raw materials are added, but also split. The finished compound feed is joined within a bag in step 7. If other raw materials are added or joined during the process step, the internal batch number of the raw material is linked to the article number and the production date.

At production step 8, the finished products are transferred to the finished product storages. A unique code is assigned to all the finished product storages. When the compound feed production is finished, a record is made of in which storage the production run is stored. The article number and production date is then recorded in combination with the unique code of the finished production storage. Again, the finished storage locations need to be reported empty every time it is empty. Samples are made of the end product, which are recorded with the article number, production date and the sampling date.

The final step is transferring the finished products to the customer. For the distribution, it is recorded from which finished storage location the end production is coming, the date, and the customer number shipment. Also the vehicle number of the carrier is recorded during distribution.

Table 2. Recording of data for pig feed traceability

1. Reception of raw materials
A internal batch number linked to the received batch of raw materials
Type and quantities of raw materials
Time of delivery
Delivery date and possible corrections to the planned delivery date
The name and address details of the supplier
The name and address details of the carrier
Method of transport
2. Storage of raw materials
Unique code of every storage location
The allocation of the internal batch number to the code of the storage location
The date the storage locations is reported empty
Storage and transport sequences
3. Weighing and dosage
An article number of the feed linked to the date of production
Weighing and dosage of raw materials from storage locations ready for production
Date and time of dosage and weighing
The allocation of raw material use (including the amount and storage location) with the article number
4. Grinding and mixing
Unique code for every grinding and mixing line

The allocation of an article number and production data to a grinding or mixing line
5. Pelletizing and conditioning
Unique code for every pelletizing line
The allocation of an article number and production date to a pelletizing line
6. Crumbling, coating and sieving
Unique code for every crumbling, coating and sieving line
The allocation of an article number and production date to a crumbling, coating or sieving line
7. Bagging
Unique code for every bagging line
The allocation of an article number to the bagging date and time, linked to the bagging line
8. Storage of finished product
Unique code of finished product storage
Article number and production date linked to the finished production storage
The date the finished product storage locations is reported empty
Random end product samples which will be labelled with the article number, the production date and the sampling date
9. Distribution
Loading storage number to customer number
Loading storage number to the licence number of the truck

The production process described in this chapter is not detailed enough for identifying the CTPs. However, it gives an indication of the production processes of the feed companies. Additionally, this information can be used as a basis for the interviews. The described information that has to be recorded is also insufficient for identifying the CTPs for the feed companies, since it is based on a research from 2002. Since then, many changes have taken place that have affected the traceability system. However, also this part will be used as a basis for the interviews.

2.4 Technology and organisation

In this part, the different elements of technology necessary for a traceability system are described. This will be followed by two concepts covering the elements of organisation. First, the managerial functions for the fulfilment of quality will be explained based on Luning, Marcelis, and Jongen (2002). Next, a description of the concept supply chain partnership is given, as an effective supply chain relies on forming partners.

2.4.1 Technology

The increasing requirements towards traceability in the food supply chain also demand advanced information technology services. A traceable system does not work without technology, since technology is necessary for product identification, process traceability, information capture, storage and linking the systems. These technologies include software and hardware (Opara, 2003). The use of an advanced information system increases the efficiency of recording data. The information provision is according to Tielemans (2004) characterized by three elements: identification, registration and administration, and linking the data.

Identification

According to Forås et al. (2015) product identification is essential for a traceability system, as it identifies the exchanged information of process and product characteristics. Identification of a batch is linking the physical batch to the information that belongs to that batch. Information about a batch can be physically attached to a product by means of a bar code, a textual code, or an electric code and are carried on a label or an Radio Frequency Identification (RFID) tag (Verdenius, 2006).

By scanning or reading the code or tag, the batch information is accessed and registered in a database. Subsequently, batch information in a database can be accessed. The most commonly used technologies for registration are a barcode scanner and a RFID reader. A barcode scanner can read a barcode and can translate this into relevant information. The bar code scanner is reliable and fast and can give additional information from the database. However, a barcode scanner cannot collect environmental information, can only read one label at a time, and is unreadable for damaged labels (Tielemans, 2004). The RFID deals with these challenges. A RFID consists of a tag, a memory and a reader which is connected to a computer system. Radio waves are used, allowing it to read from a long distance. The reader converts the waves sent from the tag into digital information that will be added to the information system. A big advantage of RFID is the enormous amount of data that can be stored on a chip (Tielemans, 2004). Besides, the RFID tags are small, can resist dust, high temperature and moisture, and have no problems with the communication with traceability databases, which makes it an effective tool for food and feed traceability. The main limitation of the RFID tag is the high costs (Bosona & Gebresenbet, 2013). Another disadvantage is that the implementation of a RFID system requires the effort of specialists (Vernède & Wienk, 2006).

Registration and administration

When the different batches can be identified, the information of each batch must be send to a data processing system. The basic functions of such a system are capturing, transmitting, storing, manipulating, and displaying of information. Such a system consists of different layers: Supervisory Control and Data Acquisition (SCADA), Manufacturing Execution System (MES), and Enterprise Resource Planning (ERP) (Figure 8). The SCADA collects and stores data from machinery and sensors on the production line. These data is then made available to the MES. MES is very suitable for recording the process characteristics of each batch. At the top level, the ERP system records and follows the material flow. ERP systems are also able to exchange information with other companies within the supply chain. An ERP system often uses the Electronic Data Interchange (EDI) for this (Klafft, Germany, Kuhn, Huen, & Wößner, 2006; Tielemans, 2004).

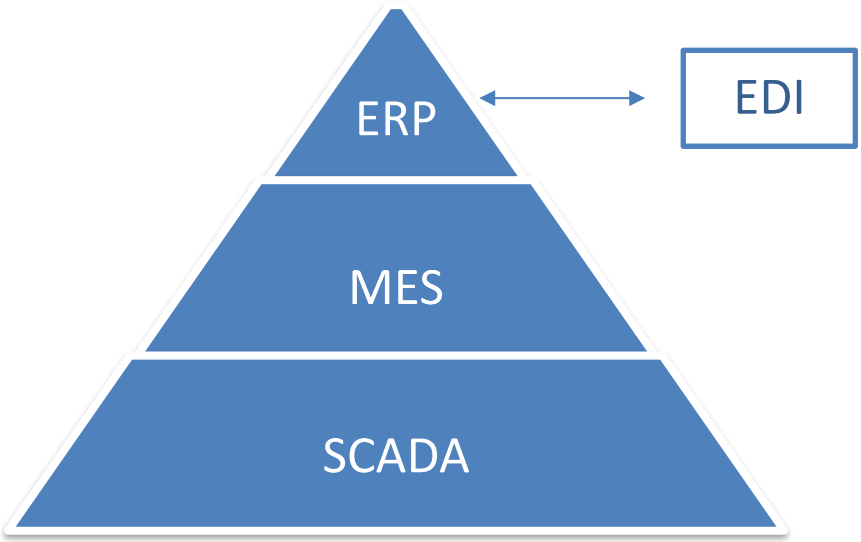

Figure 8. Software layers for a traceability system

Linking data

A feature of a traceability system is the facility for communication and information exchange. Communication between different actors in the chain is necessary in order to make traceability possible. There are several technologies for traceability information exchange such as Electronic Data Interchange (EDI) and Extensible Markup Language (XML). EDI is a set of standards that structures information in order to send the relevant information electronically between and within companies. EDI has shown to be a reliable and fast means of computer-to-computer exchange of information between trading partners within the supply chain. EDI can be used by organisations who have mature IT capabilities (Thakur & Hurburgh, 2009).

However, in the food chain there are many small medium enterprises that do not have IT experts working in their company. XML is a technology that is easy to use for organisations of any size. The purpose of XML is to facilitate the exchange of structured data among different information systems, via the internet (Thakur & Hurburgh, 2009).

The way data is stored has a great influence on exchanging information. There are three situations possible according to Vernède and Wienk (2006):

The first one is that all the companies in the chain have their own database and store information about the products and processes only in that database. The batch number should always be exchanged, as this ensures that tracking and tracing is possible. The speed of a traceability operation through the chain is lower than with a central database in the supply chain.

The second possibility is that all the companies have a central database. For each company, all the information that is relevant for their business is available. A maintainer is necessary for ensuring the security of the database. The maintainer can be the dominant company within the supply chain or a trusted third party. The technologies EDI or XML can serve as an interface between the ERP system and the central database.

The last option that can be used is that all the relevant information travels through the supply chain. The information can travel by the way of paper or electronically on, for example RFID tags. At each processing stage, information is added to the tags.

2.4.2 Organisation

Organisation is an essential component of traceability. At this level, arrangements are found that are necessary for achieving traceability. In general, arrangements for traceability systems are based on regulations, which are included in quality systems (Aung & Chang, 2014). Luning et al. (2002) identified five managerial functions that contribute to a quality system. In this research, these managerial functions will be adapted to organisation elements for a traceability system.

Arrangements have to be made for the entire supply chain, as traceability systems pass company borders. This research uses the theory of supply chain partnership, in which the key elements in reaching a successful partnership are provided. In this research, these elements will be used as organisation elements for a chain traceability system.

2.4.2.1 Managerial elements of quality control

Controlling the production process is not enough for ensuring food quality. Food quality management is much more complicated due to the unexpected behaviour of people who work with the food system and the complex character of food products. In order to ensure food quality, quality related activities are necessary (Luning & Marcelis, 2007). This is why Luning et al. (2002) identified five managerial functions that contribute to the fulfilment of quality: quality design, quality control, quality improvement, quality assurance, and quality policy and strategy (Figure 9).

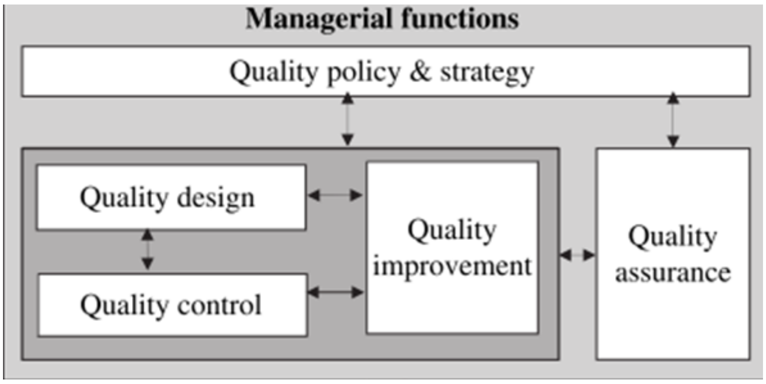

Figure 9. Managerial elements of quality control (Luning & Marcelis, 2007)

The only possibility to get a high quality in complex food products is by starting at the beginning of the production cycle. Therefore, quality should be included in the design stage of products and the corresponding production processes. As quality is defined as meeting customers' expectations, it is essential to include customer requirements into the design. After that, other requirements on the products and resources are specified, such as transport, process, suppliers, and people involved.

After a product and process have been designed, the system must be controlled during the production of food products. Quality control does not only include inspections, but also taking actions when the production does not meet the requirements. The objective of quality control is to keep products, production processes, and human processes between acceptable tolerances. It is the ongoing process of evaluating the performance and taking actions if necessary. The activities are based on gathering information in order to reduce uncertainty.

Quality improvement is of great importance in food quality. It is a systematic approach to improve a system by changing the structure. Quality improvement involves measurement, documentation, and analysis with the purpose of improving the function of the system. Quality improvement is aimed at changing people, products, and processes in order to increase their quality performance.

The aim of quality assurance is to guarantee that quality requirements are realised by the quality system and to provide confidence to customers that the quality requirements will be met. The activities of quality assurance deal with setting standards of the quality system, controlling the performance, and making changes if necessary.

Quality strategy and policy links to the quality objectives to the objective of the company. This is done by setting requirements on the quality system and on product quality levels. The objective of quality strategy and policy is to determine long term goals and objectives for food quality, and how to achieve them by the quality system (Luning et al., 2002).

Of these five managerial elements identified by Luning et al. (2002), the first two elements, quality design and quality control, will be used as elements of organisation since traceability systems are commonly based on quality systems. However, as this research is about traceability, the elements of Luning et al. (2002) will also be adapted into the following elements: traceability design, traceability control, traceability improvement, and traceability policy. Quality assurance is not used in this research, as it includes aspects of quality design, quality control, and quality improvement.

2.4.2.2 Supply chain partnership

As mentioned, traceability systems also occur between companies what can result in challenges in the supply chain. Actors in the chain can have different objectives of a traceability system. Besides, a traceability system can be expensive, so it is important that the costs and benefits are divided appropriately among the partners. Lastly, transparency between the partners is important for the exchange of information as each actor is responsible for maintaining and sharing their own information (Bosona & Gebresenbet, 2013).

In order to deal with these challenges, cooperation between people from multiple organisations in the supply chain is needed (Osinga & Hofstede, 2006). An effective supply chain relies on forming partnerships between firms that work together and share information, risks and rewards. Having a close relationship results in sharing risks with the supply chain partners and maintaining relationships over a long period of time (Ellram & Cooper, 1990). The key elements in reaching a successful partnership are trust, commitment and communication (Cutting-Decelle et al., 2007; Meng, 2012; Morgan & Hunt, 1994; Sarpong, 2014).

Trust

According to Kwon and Suh (2004), trust in the supply chain is defined as “the firm’s belief that another company will perform actions that will result in positive outcomes for the firm as well as not taking unexpected actions that result in negative outcomes”. Trust is a critical factor that enables collaboration between organisations, while a lack of trust is a major barrier for a successful partnership (Meng, 2012; Wang, Ye, & Tan, 2014). A study of Sherman and Sookdeo (1992) found that one-third of the partnerships failed because of a lack of trust between the partners.

Trust between supply chain partners leads to lower transaction costs and coordination costs, as for example a manager spends less time and energy in dealing with a trustworthy partner than when he has to deal with a unreliable partner. Besides, partners who trust each other have a more open communication and are more willing to take risks (Kwon & Suh, 2004).

Factors affecting the level of trust

Kwon and Suh (2004) did a research to find the factors that affect the level of trust in a supply chain partnership. The first factor that affects trust is behavioural uncertainty. Behavioural uncertainty makes it difficult for partners to monitor the performance, and will decrease trust of its trading partner. This is supported by Yeung, Selen, Zhang, and Huo (2009) who stated that predictable behaviour leads to trust. Repeated interaction enables one party to predict the behaviour of another party. In this research, the factor “predictable behaviour” will be used, as this positively affects the level of trust while behavioural uncertainty negatively affects trust.

The second factor that affects the level of trust is information sharing, which is seen as the most critical factor for a trust-building process and a successful supply chain partnership. Information sharing also influences predictable behaviour since more information sharing leads to more predictable behaviour, which enhances the level of trust.

The third factor is perceived satisfaction. If there is an understanding that the partnership has satisfactory outcomes for both partners, the level of trust will be enhanced.

The fourth factor is the partners reputation. If a partner has a credible reputation in a market, it shows that the partner is trustworthy. This affects the level of trust positively, especially for those who have not worked with the firm before. However, it takes time for a firm to get a credible reputation.

The fifth and last factor is shared values. Partners have a shared value if they share the same belief about what is important and what not and what is appropriate and what not. If the partners have shared values, they are more committed to their partner and have more trust in their partner.

Commitment

Morgan and Hunt (1994) define commitment as “an exchange partner believing that an ongoing relationship with another is so important as to warrant maximum efforts at maintaining it”. Commitment is the willingness of a company to work together with other firms in the supply chain. The willingness of a company to engage in an efficient and close partnership is of great importance. A company may not want to share important information with their suppliers and customers, even if it is able to (Morgan & Hunt, 1994; Zhao, Huo, Selen, & Yeung, 2011).

Factors affecting the level of commitment

Zineldin and Jonsson (2000) describe several factors that influence the level of commitment. The first factor is adaption. Adaption is the change of a product or process to suit the partner. However, adaption can also include the developing of new products or investment in lower transaction costs. Adaption shows the partner the willingness of cooperation and that the firm cares about the relationship. So, adaption positively affects the level of commitment.

The next factor that influences commitment is the relationship termination costs. Relationship termination costs are all the expected costs that will be made when a relationship will end, such as switching costs and the perceived lack of comparable potential partners (Morgan & Hunt, 1994). These termination costs lead to continuing the partnership being viewed as important, which leads to commitment to the current partnership. The higher the termination costs, the more it affects the commitment level positively.

The third factor is shared values, which affects both the level of trust and the level of commitment (Morgan & Hunt, 1994; Zineldin & Jonsson, 2000).

Communication

Communication is the formal and informal sharing of meaningful information between partners (Zineldin & Jonsson, 2000). In addition, communication can facilitate the exchange of ideas and vision, which can result in fewer misunderstandings and improve trust among the partners (Meng, 2012). Effective communication between partners is essential for achieving the benefits of a partnership.

Factors affecting the level of communication

According to Mohr and Spekman (1994), there are two aspects of communication that are critical for a successful partnership. The first aspect, participation, refers to the extent to which partners actively engage in planning and goal setting. When partners depend on each other for completing goals, the need for participation increases (Kauser & Shaw, 2004; Morgan & Hunt, 1994).

The second aspect is information sharing, that refers to the extent to which sensitive information is communicated between the partners. It reduces the possibility for conflicts in a partnership and is associated with higher levels of commitment and trust (Kauser & Shaw, 2004). A partner who communicates frequently and with a high quality level, will increase the success of the partnership.

2.5 Theoretical Framework

This research (1) identifies the CTPs and (2) examines if the elements of organisation and technology of the breeders and feed companies meet the conditions for a traceability system. The process flow and information flow are used for identifying the CTPs.

After conducting the literature research, it was found that technology has three elements: identification, registration and administration, and linking the data. Organisation consists of two main parts: managing the quality control and supply chain partnership, both having their own elements. The original elements of managing the quality control are adapted for application to traceability systems; quality design, quality control, traceability design, traceability control, traceability improvement, and traceability policy. Trust, communication, and commitment are elements used for measuring the supply chain partnership. These elements of technology and organisation will be used for measuring their influence on the traceability system. An overview of the theoretical framework is shown below in Figure 10.

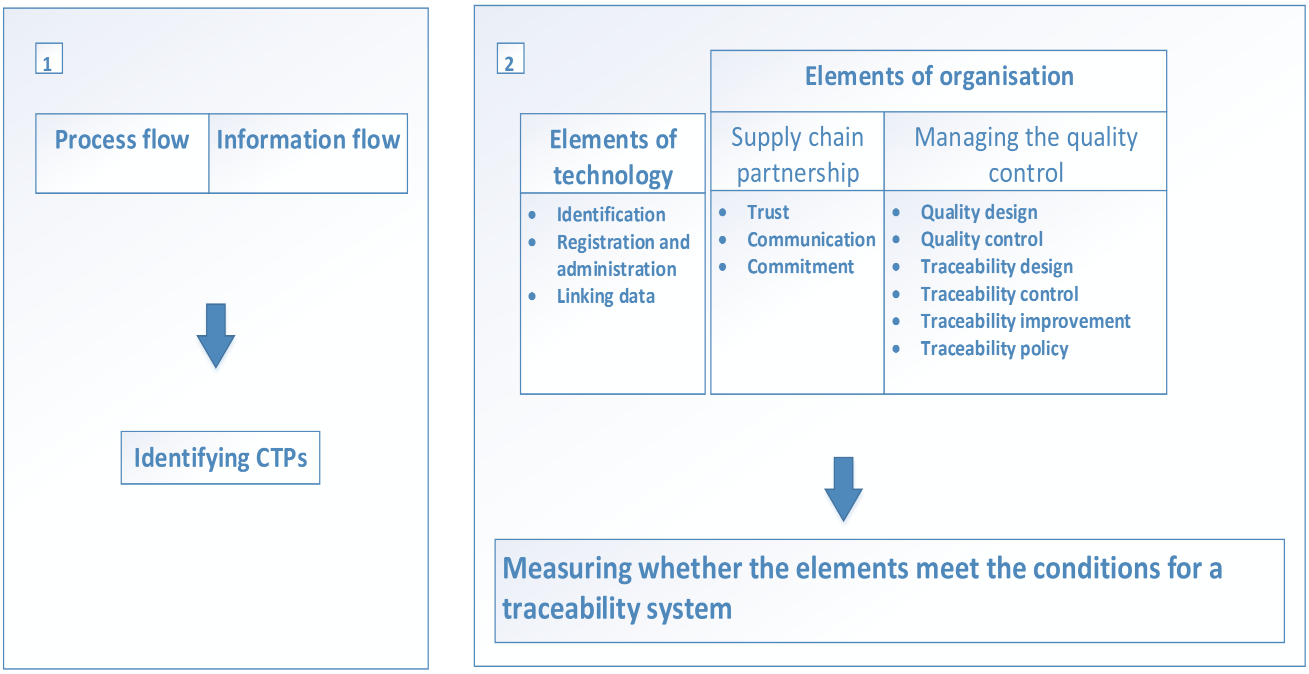

Figure 10. Theoretical framework

3. Methodology

This chapter describes the methodology that is used for this research. First the research strategy is explained, whereafter explanation of data collection follows. At the end is described how the data is analysed. The chapter ends with discussing the validity and reliability of the used method.

3.1 Research strategy

The objective was to identify the CTPs for the feed companies and whether the elements of technology and organisation of both actors meet the conditions for a traceability system. The research design of this research is a qualitative research, which fits with a case study design and is commonly used for identifying the CTPs (Denolf, 2014; Karlsen et al., 2010; K. M. Karlsen & Olsen, 2011). Therefore, semi structured interviews were conducted with the stakeholders of the Dutch pork supply chain. Besides, secondary data and a literature study were used for answering the research questions. An overview of the research method that is used for every research question, is shown in Table 3.

Table 3. overview of used method per research question.

Research question	Research method
RQ: What are the critical traceability points for the feed companies and breeders within the Dutch pork supply chain, and do the elements of technology and organisation of both actors meet the conditions for a traceability system?	Literature study
	Secondary data
	Semi-structured interviews
SRQ 1: What does the production process of the breeders and feed companies look like?	Literature study
	Secondary data
	Semi-structured interviews
SRQ 2: What information about the production process is recorded and shared between the suppliers, feed companies/breeders, and farmers?	Literature study
	Secondary data
	Semi-structured interviews
SRQ 3: Which elements of technology meet the conditions for a traceability system of the breeders and feed companies and which elements do not?	Literature study
	Semi-structured interviews
SRQ 4: Which elements of organisation meet the conditions for a traceability system of the breeders and feed companies and which elements do not?	Literature study
	Semi-structured interviews

3.2 Data collection

As shown in table 3, in this research literature, secondary data, and interviews are used for answering the research questions. In this section, the collection of data is explained.

3.2.1 Literature and secondary data

The resource engines that are used for finding the right literature were: Google Scholar, Scopus and the online library of Wageningen University and Research. First, general information about food traceability was conducted in order to provide insight in how traceability systems worked. Hereafter, literature about the four components of traceability were used in order to provide a more detailed insight of traceability. For the secondary data, different reports about feed companies, the incoming materials, and traceability of the Dutch pork supply chain were used. Additionally, the obtained data were used for the format of the interview guide.

3.2.2 Interviews

This research focused on the breeders and feed companies of the Dutch pork supply chain. Interviews have been held with employees of feed companies and breeders active in the Dutch pork supply chain. Besides, experts and stakeholders who had a lot of knowledge about the feed process, breeding, and traceability were interviewed. The main purpose was to get a clear overview of the different components of traceability at the beginning of the Dutch pork supply chain. Therefore, 12 interviews were conducted with companies active in the Dutch pork supply chain and 5 interviews took place with experts and stakeholders of feed companies, as shown in table 4.

Table 4. Role of interviewee

Companies in the Dutch pork supply chain	Experts and stakeholders
Breed companies (2)	Experts of Wageningen University (3)
Feed companies (7)	Dutch branch organisation of feed (1)
Premix company (1)	Quality assurance company of feed (1)
Farmer (2)	

Table 5 shows an overview of the 17 interviews that were held, including the function of the interviewee, the name of the organisation and the date the interview was held. Some companies preferred to be anonymous. As can be seen in table 4 and 5, most interviews took place with feed companies or stakeholders of feed companies. In addition, experts were interviewed as they provided knowledge about traceability, compound feed, breeding, or the Dutch pork supply chain. Two interviews were held with employees of large breeding companies active in the Dutch pork supply chain.

Table 5. overview of the interviews

Role of company	Function of interviewee	Name of the company	Date
Farmer	Farmer (FA1)	Anonymous	20-02-2018
Farmer	Farmer (FA2)	Anonymous	5-03-2018
Feed company	Sales director (FC1)	E.J. Bos Diervoeding	07-02-2018
Feed company	Operations manager (FC2)	Vitelia	07-02-2018
Feed company	Director (FC3)	FransenGerrits	08-02-2018

Feed company	Anonymous (FC4)	Anonymous	13-02-2018
Feed company	Quality manager (FC5)	P. Bos Veevoeders	19-02-2018
Feed company	Quality employee (FC6)	Anonymous	22-02-2018
Feed company	Quality employee (FC7)	Agrifirm	5-03-2018
Premix company	Quality employee (PC)	Anonymous	26-02-2018
Breeder	Director (BR1)	PIC-NL	16-02-2018
Breeder	Researcher (BR2)	Topigs Norsvin	27-02-2018
Dutch branch organisation of feed	Director (ST1)	NEVEDI	22-02-2018
Quality assurance company of feed	Program manager products (ST2)	SecureFeed	14-02-2018
Expert traceability	Professor (EX1)	Wageningen University and Research	19-02-2018
Expert Dutch pork supply chain	Economist pig production (EX2)	Wageningen University and Research	08-02-2018
Expert compound feed	Senior lecturer (EX3)	Wageningen University and Research	06-02-2018

The interviews were conducted face-to-face, by phone, or via skype. The face-to-face interviews were conducted on a familiar location for the interviewee. With permission of the interviewee, all the interviews were recorded. Besides, before the interviews started, permission was asked for using their name and the name of the company. The option for answering the questions anonymously was also offered.
The duration of the interviews varied per interview and per actor in the chain. The interviews with the feed companies and their stakeholders lasted the longest and took between the 35 and 65 minutes. The experts were interviewed for approximately 30 minutes. The two interviews with the farmers and the breeders lasted for 15 to 25 minutes.

Judgmental sampling

The sampling method used for the interviews was judgment sampling. The judgement sampling method is used when the researcher knows who has the required information and is willing to share this information (Kumar, 2011). This is very useful for this research as only companies where selected who had specific knowledge about aspects of traceability in the feed companies and breeders.
An e-mail was sent to several feed companies, breeders, experts, a branch organisation of feed, and a quality assurance company of feed. The e-mail included an invitation to participate in this research and an explanation of this research. Besides, the e-mail stated that they would be called within a few days. An example of such an e-mail can be found in Appendix 1. The e-mail was only sent when it was

assumed that employees of the company or the stakeholder had sufficient information about the different components of traceability.

Several companies did not react on the invitation sent by e-mail, where after they were called. Some of the companies responded that they did not want to participate, however mostly responded positively to the invitation, as shown in Figure 11 . In total, three breeders, four experts, nine feed companies, one premix company, one branch organisation of feed, one quality assurance company of feed, one branch organisation of farmers, two farmers, and six consumer or environment organisations were approached (28). When a company was willing to participate, an appointment for an interview was made on location or by phone.

Unfortunately, none of the consumer or environmental organisations wanted to participate for the same reason: each week they receive multiple requests for information and interviews which they cannot fulfil due to their limited (time) capacities.

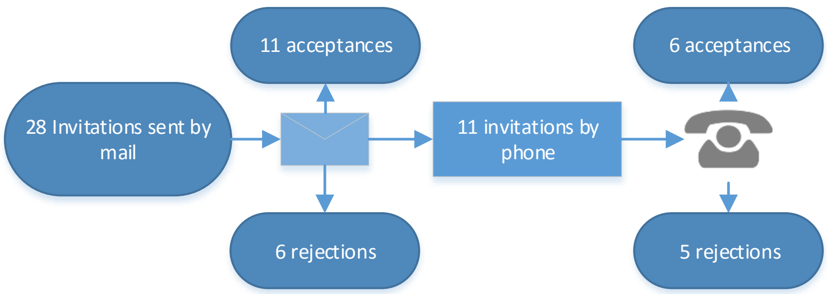

Figure 11. Flow chart of invitations

Interview guides

One interview guide was made for each actor in the chain, resulting in 5 different interview guides. Moreover, the interview guides were slightly adapted for each interview as each interviewee had different knowledge about traceability at the beginning of the Dutch pork supply chain. The adaptions in the interview guides for example included that a part of the questions was not asked to the interviewee because he or she did not had sufficient knowledge about this subject. For example, an expert of traceability has no knowledge of the process flow of feed, so questions about this subject were not asked to him.

The questions that were asked during the in-depth interviews were semi-structured, where the framework with topics for the interview guide was based on the four components of food traceability. The semi-structured interviews also allowed the interviewer to ask other questions during the interview if the response of the interviewee opened new possibilities. An example of an interview guide can be find in Appendix 2.

Each interview guide consisted of five parts, namely: a general question, process questions, information questions, technology questions, and organisation questions (quality questions and supply chain partnership questions). The process and information questions were used for identifying the CTPs and the technology and organisation questions were used to examine whether the elements of technology and organisation of both actors met the conditions for a traceability system, as shown in the theoretical framework. The five parts are explained below including examples of the questions asked. An overview of all the questions can be found in Appendix 2.

1. General question

The general question was meant to help the interviewee to get comfortable during the interview. This general question was about the function of the interviewee, which was easy to answer for the interviewee.

2. Process questions

The process questions were based on the process traceability and the process flow of the feed companies, described in the literature review. The process questions were asked to get a clear overview of the production process of the breeders and feed companies. Additionally, as the feed companies receive many materials, several questions were asked to get a better understanding of the material flow to and from the feed companies (Table 6). Besides, other questions were asked to find out where transformations of batches occur during the production process and material flow.

Table 6. Examples of process questions.

Examples of process questions
Which materials are used in the production process and where are they coming from?
How does your production process look like? (using Figure 9 (P.16))

3. Information questions

The information questions were based on Tielemans (2004), described in the literature review, and the research of PDV (2002) from 2002. These questions concerned the information flow within the feed industry and breeding industry regarding traceability (Table 7). Additionally, questions were asked about what information is collected and stored during the process flow. Special attention was paid if the transformations were recorded and if the traceable units were uniquely identified, as these are normally the bottlenecks of traceability systems.

Table 7. Examples of information questions

Examples of information questions
Which information is collected when a batch of materials is received from a supplier?
How is information recorded when batches are joined in a silo?

4. Technology questions

The technology questions were asked based on the three elements of technology found in the literature: identification, registration and administration, and linking data. The questions about technology were asked to get insight into the technologies used for identification and registration and administration. Also, these questions provided insight into how information about the incoming batches or compound feed is exchanged between actors in the supply chain (Table 8).

Table 8. Examples of technology questions

Examples of technology questions
How is information about incoming batches identified? (using barcodes, RFID readers?)
Which data systems are used for the registration and administration of the information? (ERP, MES)
What technologies are used for exchanging data?
Do you share a database with other actors in the chain?

5. Organisation questions

As showed in the theoretical framework, organisation consists of two parts: managing the quality control and supply chain partnerships, each having their own elements. The first part consists of questions about the quality systems of the companies and where this quality system was based on. Additionally, questions about the traceability system were asked, such as what it was based on, if the system was controlled, and whether they came to improvements of the traceability system.

In the second part, the interviewees were asked about the partnership at the beginning of the Dutch pork supply chain. These questions were based on the three elements of the concept supply chain partnership: trust, commitment, and communication (Table 9).

Table 9. Organisation questions

Examples of organisation questions
How is quality system designed and on which quality system is it based on?
How do you come to improvements of the traceability system?
Do you share enough information with your farmers?
Are partners involved in the traceability goals of your company?

3.3 Data analysis

All the interviews were recorded in order to make transcripts of each conducted interview. These transcripts were used for analysis. The transcripts about the feed industry and breeding industry were coded so that they could be used without reading the entire transcripts again. Coding was based on Gordon (1998). First, the coding categories had to be defined. These categories were based on the four components of traceability, where the organisation component was divided into two categories. The advantage of using the components of traceability as category is that the interviews were also structured based on the four components of traceability, making it the same order. As each category had its own elements, subcategories were also used. Each category got its own symbol, which could be a number, a letter, or a colour. In this research each category got its own colour and each subcategory a code. An overview of the coding can be found in Table 10.

Table 10. Coding of the transcript for the feed industry

Category	Colour	Subcategory	Code
Process	Blue	Material flow	MF
		Production process	PP
		Transformations	TRA
Information	Green	Receiving information	RI
		Storage information	SI
		Production information	PI
		Delivering information	DI
Technology	Orange	Identification	ID
		Registration and administration	RA
		Linking data	LD
Quality	Red	Quality design	QD
		Quality control	QC
		Traceability design	TD
		Traceability control	TC
		Traceability improvement	TI
		Traceability policy	TP
Supply chain partnership	Purple	Trust	TRU
		Commitment	CM
		Communication	CC

The difference in analysis between the breeders and the feed industry was that the subcategories were not used for the breeders. The amount of information that is conducted was much less, so the five main categories were enough for analysing the data.

After the interviews, the results of ‘process’ and ‘information’ were used for identifying the CTPs for the feed industry and the breeders. After the CTPs were identified, the categories ‘technology’, ‘quality’, and ‘supply chain partnership’ were analysed based on their elements to examine whether the elements of technology and organisation of both actors met the conditions for a traceability system.

3.4 Methods validity and reliability

For this research, seven out of the eighty compound feed companies that are active in the Netherlands were interviewed. Besides, of the three major feed companies active on the Dutch market, two were interviewed, namely Agrifirm and De Heus Voeders. As two important stakeholders of the feed sector were also interviewed, SecureFeed and Nevedi, the outcomes could be generalised to the entire pig feed industry. Since the interviewed companies also produce feed for cattle and poultry, with almost the same production process, the outcomes of the pig feed industry could even be generalised to the entire Dutch feed industry.

Two out of four active breeders in the Netherlands were interviewed, of which one was Topigs Norsvin which has the largest market share. As the interviews with the breeders were only to get insight in what role traceability played within the breeding sector, two interviews were sufficient to obtain the needed information.

Some of the interviews were done by phone, since this decreased travel time and it enabled the interviewer to interview feed companies dispersed over the country. Also, a telephone interview can make sure that a interviewee is more relaxed, as many interviewees asked for an interview over the phone when was asked to conduct an interview. There was no difference between the duration of interviews conducted by telephone or face-to-face. A disadvantage of a telephone interview however is that there is an absence of physical contact, whereby interpretation of body posture is not possible.

The invitations were send to the feed companies, their stakeholders, and the breeders, but they were not addressed to a specific person. In this way, there was no influence on which person could be interviewed. To ensure that the selected person for the interviews had sufficient knowledge about traceability, the four components of traceability were briefly explained in the invitation. This resulted in interviews with employees of the feed companies, their stakeholders and breeders who had the needed knowledge to answer the questions.

In total, there were 28 people or companies invited to participate in this research of which 17 did participate. This is a high response rate. However, of the six consumer and environmental organisation that were approached, none wanted to participate.

4. Results

This chapter presents the results of the interviews. First, the process and information elements within the feed companies, farmers, a branch organisation of feed, a quality assurance company of feed, and the experts are analysed. By analysing these results, the CTPs are identified for the feed industry. Hereafter, technology and organisation elements are analysed to determine if they meet the conditions for a traceability system. Lastly, the results of the interviews with the breeders are provided, based on the same categories.

4.1 Feed industry

4.1.1 Process

Material flow

According to all the feed companies and stakeholders of the feed industry, the materials that the feed companies receive come from all around the world. SecureFeed distinguishes 600 different materials (ST2) and the company of respondent PC even has 700 different materials in stock. However, the twenty most used materials cover approximately 80% of the total amount of materials the feed companies use (ST2). According to the respondents, the main raw materials that are received are soy, palm kernel flakes, sunflower flakes, rapeseed, and cereals, like barley, wheat and maize. Feed companies also receive liquids like salmon oil and animal fat. Besides, by-products from the food industry are used in the feed.

As mentioned before, the materials for producing feed come from all over the world, however each material has its own origin (FC7; ST2). An overview of each incoming material and its origin can be found in Table 11 on the next page. Soy products mainly come from Brazil and Argentina, and with the development of regional soy production, there is now also the Balkan soy (ST2). Palm kernel flakes are mainly imported from Malesia and Indonesia and sunflower flakes are mainly coming from Ukraine (FC1; FC2; FC3; FC5 ST2). Rapeseed straw comes from Germany and Denmark (ST2). Some companies receive their cereals from all around the world (FC6), while others receive their cereals mainly from Europe (FC3; FC5). Wheat and Barley are mostly coming from Netherlands, Germany, Belgium, and France, while maize is coming from more far away, like Russia, Poland, Slovakia, Czech Republic, but also Brazil (FC5; ST2). Oat origin is of a more northern origin, such as England and Denmark (FC5; ST2). By-products are mainly from countries that are close to the factory like Belgium, Germany, and the Netherlands (FC2; FC3; ST2). Fat products mainly come from Scandinavia. For fish products, there are really strict rules. Inland seas, for example, are forbidden because of possible environmental impacts. Therefore fish products are mainly coming from Scotland, Norway, Iceland, or South-America (ST2).

Feed companies also receive premixes. Vitamins, minerals, and additives are included in a premix, which is made by special premix companies. The materials used by premix companies also come from all over the world (PC; ST2).

Table 11. Materials and their origin

Incoming material	Origin
Soy	Brazil and Argentina
Palm kernel flakes	Malesia and Indonesia
Sunflower flakes	Ukraine
Rapeseed	Germany and Denmark
Barley	Netherlands, Belgium, Germany, and France
Wheat	Netherlands, Belgium, Germany, and France
Maize	Russia, Poland, Slovakia, Czech Republic, and Brazil
By-products	Netherlands, Belgium, and Germany
Fish products	Scotland, Norway, Iceland, and South-America
Materials premixes	All over the world

According to respondents FC3 and FC4, it depends on the material how often it is supplied to the feed company. Some materials are received each day, while there are also several materials that are received only a few times a year (FC4). The company of respondent PC for example receives five trucks of the material chalk every day and the company of respondent FC2 each day receives 30 trucks with different materials.

Some feed companies receive their materials by trucks and ships (FC6; FC7; ST2). There are in the Netherlands only twelve companies that can receive materials by ships at their factories. This means that they are large enough and have factories near water, for example the feed company of respondent FC7 where between 80% and 90% of the materials is delivered by ships and also owns 40 ships itself. A delivery by ship is much cheaper than to get the same delivery with many trucks, as a ship has a cargo capacity of approximately 2500ton and a truck of 30-40 ton (FC7; ST2).

Feed companies that are not located near the water receive deliveries by trucks. However, it is still possible for them to buy a cargo of materials brought with a ship (FC1; FC5; ST2). According to respondent ST2, the ships are usually bought by buying organisations, which buy materials loaded in one ship for ten feed companies. The materials are then stored at a transfer location for example in Rotterdam, Dokkum, or Deventer. The feed companies can pick up their part with trucks and when it runs out, they buy a new cargo of a ship (FC5; ST2). Respondent FC7 said about delivering materials by trucks: *"We cannot imagine that you still make feed only supplied with trucks. Not in the way we make it"* (FC7).

Production process

The production process is according to all the respondents almost always the same for the pig feed companies. It starts with receiving the raw materials, which are brought by ship or truck. The raw materials are then blown into the silo, where the materials of the same product are joined. Based on the recipe of the end product, the raw materials are dosed and weighed. Weighing takes place before the materials are used and almost always happens automatically.

Most of the received materials still need to be grinded, as the received materials are pelletized. According to respondent FC7, transporting pelletized products is cheaper. The materials are reduced in size in the grinder, which improves the ease of handling the materials in the production process. These materials, such as maize and wheat, go together in the hammer mill. Usually the materials are first joined before they go into the hammer mill, which is called mixed grinded. It is also possible that materials are independently grinded, where after the materials are joined (FC5).

The materials that are already grinded such as salt, lime, chalk, liquids, premixes, and vitamins pass the hammer mill and are joined together in the main mixer. After the mixer, it goes to the conditioner where steam is added. Here after it goes to the pelletizer where it becomes pelleted feed. Then, the pelletized feed is cooled, where after the feed is usually stored. According to respondent FC7, the production process for making feed is a semi-continuous process. So, a batch is weighed and dosed, which takes six minutes. At the same time, a batch is getting mixed in the mixer for six minutes, and another already mixed batch is transferred to another location in 6 minutes. After six minutes, when the batch in the mixer is mixed, it is transferred, and within one second, the batch that has been weighed and dosed, is going into the mixer where it will be mixed.

The end product is stored to improve the quality of the feed or to ensure that the end product is finished when the truck arrives (FC5). It then goes into to the truck to the farmers, which usually happens within one day. It is also possible that the end product goes to the bagging line, where the end product is packed in bags of mainly 25 kilogram. However, most feed companies do not keep the feed in stock, as almost all the feed is custom made. The end product is delivered to the silo of the farmer where the feed company knows in which silo it has to deliver (FC6). An overview of the production process of the feed companies is shown in Figure 12 on the next page.

The premix companies are specialized in combing micro products that a feed company cannot buy separately (ST2; EX3). The premix companies make premix bags that are delivered to the feed companies. The premix is mostly linked to the production process, so the premix producers make the premix in such a way that the feed companies can work with whole bags. Some feed companies have their own premix factory (FC4; FC6; FC7).

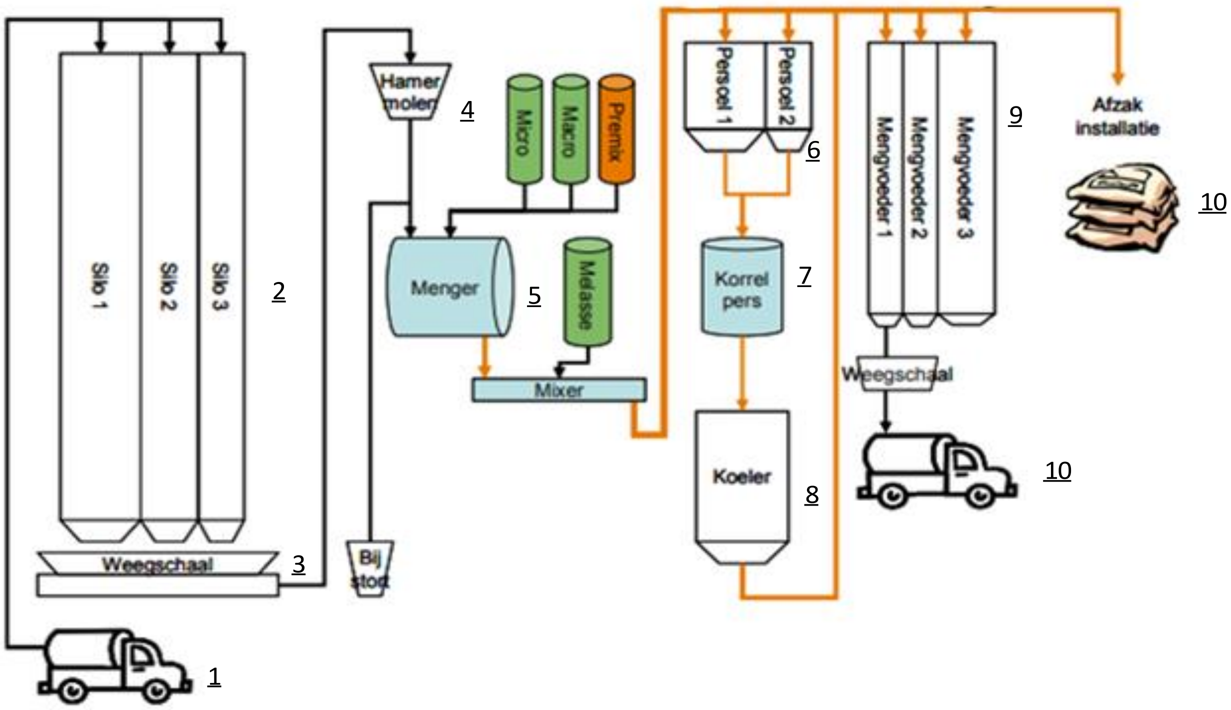

Figure 12. The production process of a feed company (Zuidema et al., 2010)

(1. The truck or ship delivers the raw materials to the feed company, 2. The materials are stored in the silo, 3. The materials are weighed and dosed, 4. Materials go through the grinder, 5. Materials are joined and go into the mixer, 6. Steam is added to the materials, 7. The materials go into the pelletizer, 8. The feed is cooled, 9. The feed is stored, 10. The feed goes into the truck to the farmer or the feed goes into bags for stock)

Samples

According to respondent FC1, FC4 and ST2, it is required by Good Manufacturing Practise+ (GMP+), SecureFeed, and law to take a sample of each material that comes in and a sample of each batch of end products that goes out as well. These samples need to be saved for six months. A feed company needs to take samples for their GMP+ certification, but also for their traceability system. A sample shows of what the material consists. This means that it measures the characteristics and the nutritional value: the energy, fat, and protein value and the moisture level of the material (ST1). Back in the days, samples were only taken of the end products. However, nowadays the focus is on taking samples of incoming materials: *"The last years we mainly look at what comes in, because you want to know whether it is safe before it goes through the entire production process. When you only measure the end product, then you are already too late and you do not know what the problem was"* (FC4). By doing this, feed companies know exactly what they buy (ST1; EX3). Taking samples are a double check to see if everything is fine and according to the law and contract. According to respondent ST1, an investigation of the materials takes a week. So, the materials are already used by that time, assuming that the sample is correct and that the supplier delivered according the contract and laws: *"If it does not meet the requirements, they have a problem with each other".*

There are different ways to take samples, where one is better than the other: *"The worst way of taking a sample is by taken a sample at the outflow of a truck. That is not an average sample of the batch. A good way is to take a small amount of the entire truck"* (ST2). Respondent FC4 mentioned that they use a kind of a tube, which goes to the bottom of the truck in order to have a sample of the entire material and not just from the top: *"It has happened that at the top of the batch, the quality was better than it was at the bottom of the truck. Now that the suppliers know we use this system, they will not try do to manipulate the quality like this"* (FC4).

Some feed companies have a Near-infrared spectroscopy (NIR) which measures everything directly. In one minute the most important characteristics such as the energy, moisture, fats, and protein value of the material are known. In this way, the critical materials are analysed before the materials are unloaded (FC4; FC7; ST1; ST2; EX3).

Transformations

According to respondents FC1, FC5, FC7, ST1, and ST2, many transformations occur during the delivery of materials from the location of origin to the feed company. According to respondent ST1, the soy, for example, is stored in terminals where the soy is collected from an average of 20.000 hectares in the area where it is produced. Hereafter it goes to the traders, who collect the soy in their own storage places close to the harbour. Then, the soy is transported to Europe in a ship with a batch of 11.000ton. Next, the shipload is split into 5 ships of 2000ton. The same procedure applies when a ship delivers raw material for more companies. Each company gets a part of the material that is brought by the ship and the batch is split again. *"The soy is already split and joined 10 times before it reaches Europe and it is hard to tell where it is exactly coming from. The only thing that is possible is that you know that 70% of the materials of a ship is coming from a certain area. It is possible of course, but then you never make competitive feed"* (ST1). *"If you have maize from Ukraine, it is not that each farmer brings his maize to here. It does not work like that"* (FC7).

According to respondents FC1 and ST2 this also applies to farmers that sell cereals: they have storage places where the cereal is stored together in a couple of silos. Here after, the different parts are sold to the customers, where it is split again. *"We trace it back to particular suppliers, and the batch that is delivered by them. What happened before, we do not always know"* (FC5).

When asking the respondents whether the materials are joined or split by the supplier, some answered that transformations only happened in the premix factories (FC2; FC3).

According to most of the respondents, transformations also occur in the factories. An overview of the transformations that occur per production step in the feed company is shown in Figure 13 on the next page, which is an expansion of Figure 9 based on the interviews. It starts in the silos where different batches are joined. This is inevitable, as no feed company has space for one silo per batch (FC6; PC). Respondent FC7 mentioned that it is not possible to keep everything separated. According to respondent ST2, the silos are emptied, but not after each supply: *"As a company, you try to get a zero point once in a while in order to have the right stock in the administration, to clean the silo, but it is difficult to get an empty silo as there is mostly a shortage of silo space"*. According to respondent ST1, the joining of batches only happens when the material and the quality of the material are the same.

The respondents mentioned that different materials are also joined at the weighing and dosing before they go in the hammer mill. However, a batch of material is also split, because only a part of a batch that is stored in the silo is used for producing feed.

In the mixer, the liquids, additives, and premixes are added. Before pelletized feed is produced, steam is added first. Finally, the end products are joined in an end silo. If a farmer orders 50ton of feed, and a production run can make approximately 6ton of feed, 8 production runs are collected at the end silo since it is collected in one truck. The same applies for feed that is produced for stock, where the end product is saved in a silo that comes from several production runs (FC7).

Transformations also occur when the feed is delivered to the farmer. It is possible that a batch is stored in a silo where another batch is still present (FC6; FC7; FA1; FA2). According to respondent FC6, it is the responsibility of the farmer to clean the silo and to record this information. If something happens, both batches are considered suspicious (FC4).

Respondents EX3, FC1, FC5, FC6, and FC7 mentioned that transformations of materials are a challenge for the traceability system. Respondent FC7 said about this: "Making feed is not difficult, but it is one of the most complicated processes for tracing materials back. The factories are not made to have an easy traceability system". An additional reason why this is so difficult, according to FC5, is because a raw material batch can be used for 100 production runs, so it can go wrong 100 times.

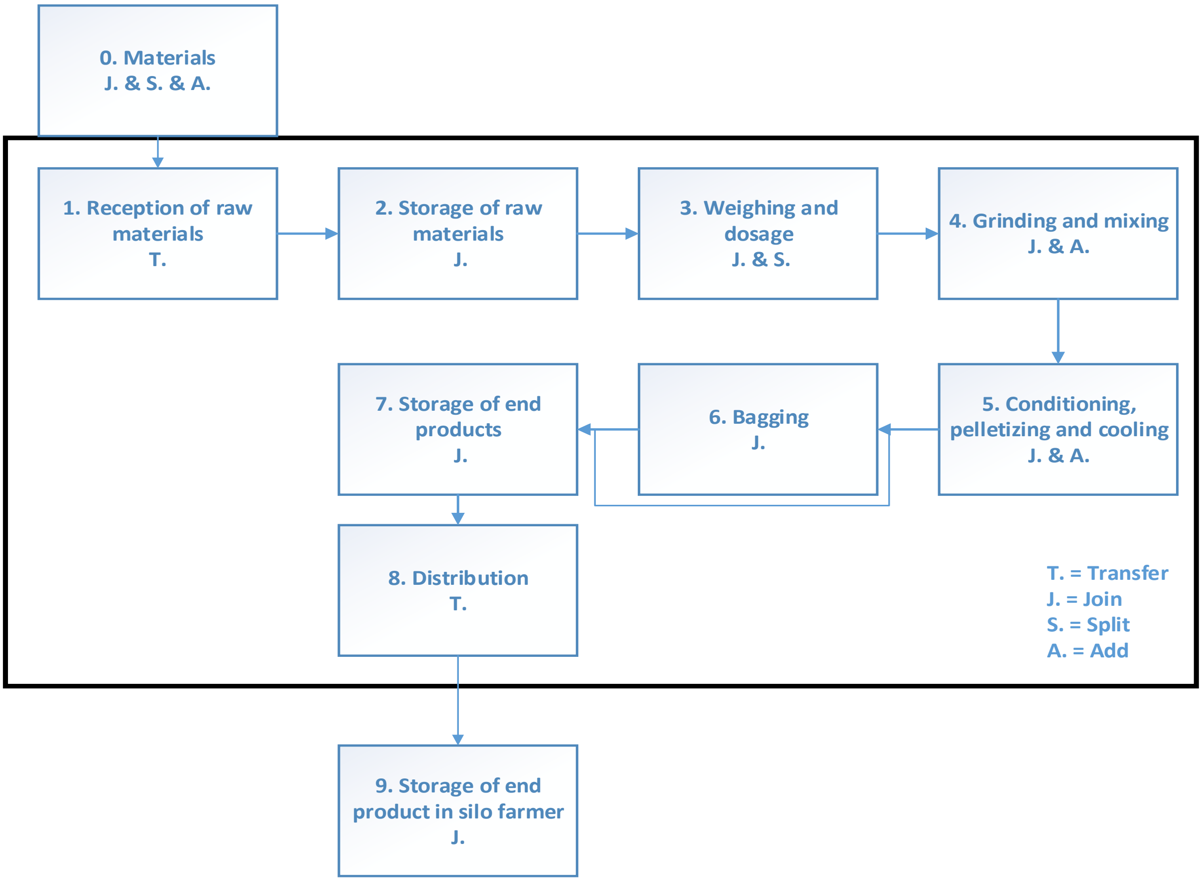

Figure 13. Transformations in the feed supply

4.1.2 Information

Receiving information

According to the respondents, many information is saved when materials are delivered at a supplier: a product certification including the specifications, the name of the supplier, the previous trucks that are used, whether the truck is cleaned, the three previous materials that were delivered by the truck, the date, the unloaded and loaded weight, the place where it is loaded, and the signature of the truck driver. All the respondents mentioned that they have their own codes for the materials they use, where each feed company uses different codes. The codes do not match with the codes of the supplier, as they have their own codes.

For each supply to a feed company, an order number is sent from the feed company to the supplier (FC2; FC3; FC5; FC7; ST2). When the supplier delivers the material, the truck driver has to show this order number. Without the order number, the delivery is not accepted. This is for some companies really important: *"We do this because there is another compound feed company in this street and they sometimes have the same suppliers. It happens that a truck that is meant for them comes to our factory and the other way around"* (FC5). Additionally, according to respondents FC2, FC3, and FC7, this code is important for traceability as it links the incoming batch and the sample that is taken of the batch with the delivery of the supplier.

Storage information

For tracking and tracing, each respondent mentioned that they work with a safety margin of 30% when batches are joined in the silo. This means that if something happens, for example there is a recall because a batch does not meet the requirements of food safety, the detected batch is tracked and traced to find where it is located. Subsequently, 30% of the batch before and 30% of the consecutive batch is also tracked and traced to ensure that the entire detected batch is removed (FC3). According to respondent FC3 and ST2, this is because the outflow causes that not the oldest batch is flowing out first. It can happen that the second batch is flowing out before the first batch is out of the silo, depending on the construction of the silo (FC1; EX3). The recording of the outflow and the recording of the safety margin are included in the software (FC7). Respondent FC7 explains how this works: *"Batch Y is used for the first time at 10 o'clock. However, there is a 30% joining as batch Y is deposited above batch X. You dosage until batch X is theoretically used. Then batch Y used, this is theoretical of course, because it is already joined with X. So we calculate back, how much earlier batch Y is used then 10 o'clock. So for batch Y, the time is used when the last 30% of batch X is used. This is then the starting time of batch Y, as safety margin".*

All the respondents said that their feed company has an unique code for each silo. When a batch is stored in a silo, this is automatically recorded, as well as the recording of the outflow.

The silos are temporarily cleaned, which is also required by law (ST2). According to respondents FC2 and FC5, it is essential to clean and empty the silos as often as possible, because if something happens, you do not know which batch you have to trace back. The respondents mentioned that they try to empty the silos as often as possible. However this is not easy: *"They need to be empty sometimes. But of course, we are a large company and before you know it, the silo is full again"* (PC).

Production information

According to the respondents, all the materials that are used are weighted. This happens almost always automatically, but sometimes also manually. The materials that are weighted manually are usually small materials. They lie in a bag near the mixer and are added manually to the mixer (PC; FC7; ST2; EX1; EX3). Since only a small amount of these materials is added and they are used only once in a while, these materials are not weighted with a large machine but manually, by making use of barcodes and other readers (PC; FC7; ST1; ST2). According to FC5, PC, ST2, and EX3, manually weighing and manual joining is more sensitive for errors compared to automatically weighing. It can happen that someone does not pay attention (FC5, EX3). According to respondent PC, it is possible that bags that are used for manual joining cannot be traced back: *"An open bag is used multiple times, and because it is not full, it is not possible to scan it"*.

Besides the weight of the materials, the respondents mentioned that there is many other information stored during the production process to ensure traceability. When the production starts, a new batch number is created and linked to the farmer order. Other information that is captured and linked to the batch is which materials are used, from which silos they came, which line is used, the amount of end products there is made, to which end silo it goes, and the time the production starts. According to ST1, everything that goes through a feed factory is followed: *"It does not happen that there are materials used of which nobody knows where they are coming from"*. Additionally, many other information per production run is saved. Examples are the temperature, how much steam is added, the time the mixer starts, the power consumption, and the crushing diameter. All this data is captured automatically (FC4; FC7)

Delivery information

The farmer gets a delivery note with information about the amount and weight of the feed, the article types, the name of the client, in which silo the feed is delivered, the date, the truck that delivers, the part of the truck where the feed was stored, and the location where it was processed for feed companies with several factories (all the respondents of the feed companies). On the backside is a label with information about the used materials, but the amount is not included as this is not required (FC3; FC5; FC7). The feed companies have to indicate the materials that are used in the order of which material is used most: *"So if maize is 17% of the feed and Barley 16%. Maize comes first, and then Barley without the percentage. This is according to the law, but the law does not require to mentioning the percentage, as this is 'intellectual property'. We have a lot of knowledge which we use to make the right feed. The law accepted that we have to say which materials are used but not exactly how much"* (FC7).

With this delivery note number, the feed company can exactly see what happened during the production process and which materials were used. *"With the combination of the order number and the article number, we can trace everything back in our system"* (FC1; FC2; FC7). According to respondent FC6, the feed company always has this number in their system, so it does not matter if the farmer does not have the delivery note anymore. Respondent FA1 said that it happens that the delivery notes are blown away, while the farmers have to save it officially for three years.

An overview of the data that is recorded at the pig feed companies can be found in Table 12.

Table 12. Recording of data for pig feed traceability (Updated from Table 2)

1. Reception of raw materials
An internal batch number linked to the received batch of raw materials

Type and quantities of raw materials
The loaded and unloaded weight
The place where it is loaded
The delivery data and time
The name of the supplier
The name and address details of the carrier
The signature of the truck driver
Method of transport
Whether the truck is cleaned
The three previous materials that were delivered by the truck
Samples linked to the received batch
2. Storage of raw materials
Unique code of every storage location
The allocation of the internal batch number to the code of the storage location
The date the storage location is reported empty
Storage and transport sequences
A safety margin of 30%
Date and time of a batch that is stored
3. Weighing and dosage
An article number of the feed linked to the date of production
Weight and dose of all the raw materials from storage locations ready for production
The weight and dose according to the recipe
Date and time of dosage and weighing
The allocation of raw material used (including the amount and storage location) with the article number
4. Grinding and mixing
Unique code for every grinding and mixing line
The allocation of an article number and production data to a grinding or mixing line
Date and time of grinding and mixing
The materials that are joined and added
5. Conditioning, pelletizing, and cooling
Unique code for every pelletizing line
The allocation of an article number and production date to a pelletizing line
Date and time of conditioning, pelletizing, and cooling
6. Bagging
Unique code for every bagging line
The allocation of an article number to the bagging date and time, linked to the bagging line
Date and time of bagging
7. Storage of end product

Amount of end products made
Unique code of end product storage
Article number and production date linked to the end production storage
The date the end product storage location is reported empty
End product samples which will be labelled with the article number, the production date and the sampling date
8. Distribution
Loading storage number to the farmer number
Loading storage number to the licence number of the truck
The weight that will be delivered
The date and time when a truck delivers the end product
Which part of the truck is for which farmer
9. Storage of end product in silo farmer
Delivery note number
The name of the client
The silo in which it is delivered
The amount and weight

4.1.3 Identifying CTPs for the feed industry

The traceability systems in the feed companies are of a high level, in which all the materials that are used within the feed companies are uniquely identified and all the transformations that occur within the feed companies are almost always automatically recorded. Besides, the information about the ingredients and transformations are connected to the end product, which ensures that an end product can be traced back to the used materials within the feed companies. However, there are some CTPs identified where information of the feed may get lost in the feed industry. To repeat, CTPs are “points where information loss may occur due to possible loss of identification and flaws in registering transformations”.

CTPs

The supplier does not deliver codes for the materials when he delivers to the feed company. As a result, information about the materials gets lost since information is not exchanged when the feed companies receive the materials. The reason for this may be the lack of standardisation in the supply chain.

All the transformations during the production process of feed are recorded, mainly automatically. However, a small part is done manually, for example the weighing of small materials (CTP 2). Besides, also the joining of small materials in the mixer is sometimes done manually (CTP 3). This is not desirable for a traceability system because manually weighing or joining can cause mistakes and mistakes may lead to information loss about the transformations in the feed companies.

The feed companies also do not deliver codes to the farmers or information about the production process. So information about the feed gets lost here (CTP 4). Besides, it happens that batches of feed are joined in the silo of the farmer. The outflow is not recorded, which means that the transformations in the silo are not recorded (CTP 5). An overview of the CTPs found in this research is shown in Figure 14.

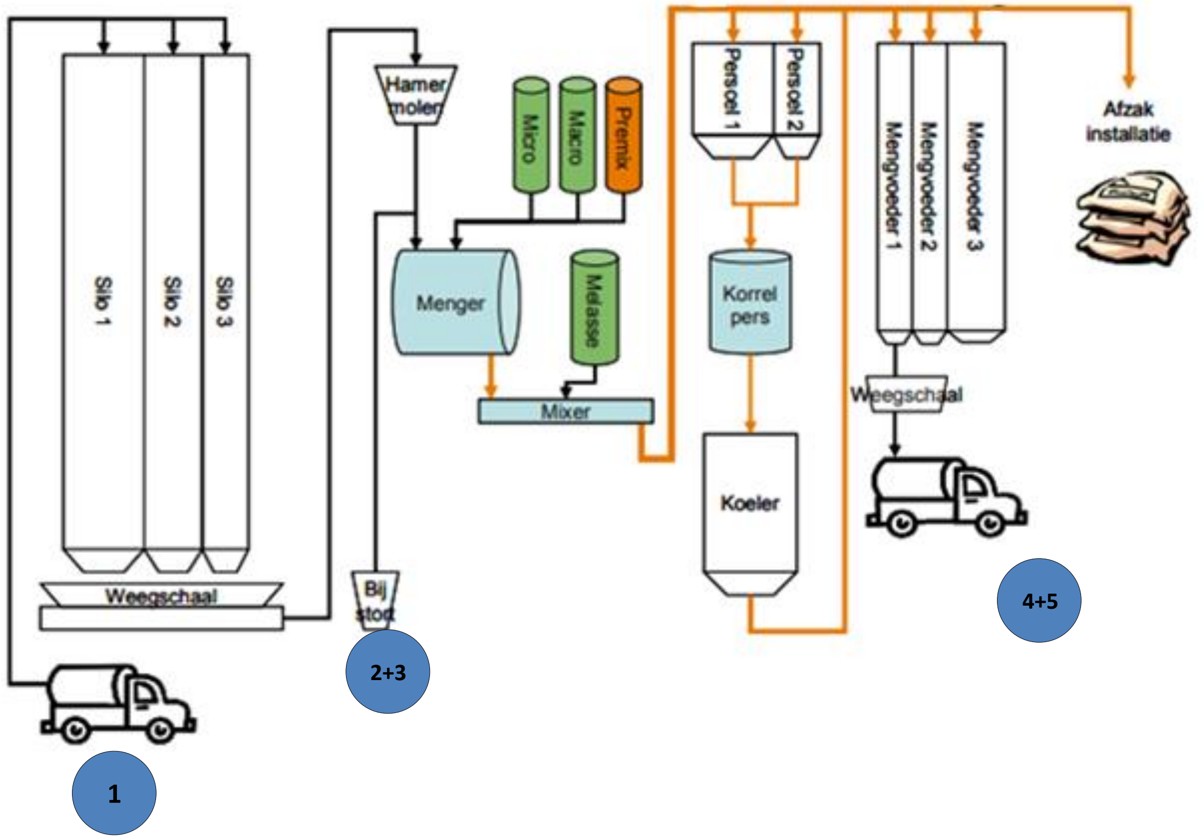

Figure 14. The production process including the CTPs for the feed industry

Many transformations also occur before the feed companies receive their materials. This could also be a CTP, however, according to the respondents, it is impossible to get a batch of raw materials directly from a farm overseas, while making competitive feed. This is why each incoming ship or truck with raw materials, is seen as a batch by the feed companies. A sample of each incoming batch is taken, to ensure that the incoming materials are safe and have the right values. This does not mean that information about the incoming materials cannot be shared in the chain.

4.1.4 Technology

Technology is important for a traceability system and therefore it should work correctly. Respondent FC4 mentioned that it can also be a challenge to not get a virus, as everything is more and more depending on electricity and technology. According to him, everything should function as it should, the power should not fail, internet and mail must stay working, and no cable should be pulled through. This is supported by respondents FC6 and PC, who also stated that the technology must work correctly.

Identification

Barcodes are used in all the factories when bagged goods such as premixes or additives have to be added to the mixer. *"The barcode is scanned first, where after it is allowed to add the bagged good to the mixer"* (FC4; FC6; PC; FC2). The bagged good is then automatically debited (PC), and the amount that is used is automatically processed in the system (FC3). Respondent FC3 investigates the possibilities to expand the use of barcodes.

Some respondents mention that the information of incoming materials is all automatically processed into the feed companies' software systems (PC; FC7). Other respondents mentioned that information about incoming batches is automatically and manually entered into the system (FC5; FC6). *"You do not want people entering data, because they make mistakes. So you need automatic devices. These need to be trustworthy, which is quite easy nowadays"* (EX3).

Registration and Administration

Feed companies have software systems from different brands where information is stored and displayed. Several feed companies use ERP as software (PC; FC2; FC4; FC7), another feed company uses MES (FC1), and one feed company mentioned to have both ERP and MES systems (FC3). Information about the materials, logistic information, and product information are all linked (FC1; FC3; FC4; FC7). As already told, production information is automatically recorded in the software systems according to all the respondents. Respondent EX3 mentioned that ERP is a good system as it has a lot of facilities which can be used for traceability.

Respondent FC7 mentioned that his feed company uses different software systems at each factory for each factory, as it was modernized in time. When there is a recall, the local factory has to search the information in their process computer (FC7). Respondent FC3 also mentioned that the factories of his feed company use different MES software systems.

Linking data

All the feed companies shares information to the farmers only face to face, on paper via the delivery note, or via an invoice sent by mail (FC1; FC3; FC4; FA1). There is no feed company that has a combined database system with the suppliers or farmers.

At one feed company, they nowadays use technology by which some farmers can log in into the system for ordering feed (FC4). Another feed company has an app in which a farmer can make an order when he sees that the silo is almost empty. The order goes automatically to the schedule system of transport and the schedule system of production (FC7).

Respondent ST1 sees sharing information and linking systems as a challenge for the feed companies. *"Ensure that your data is well organised, knowing what is coming from you and knowing how essential information has to be delivered in the right format with the person who can continue with it"*. Respondent ST1 said that this will not change within one year, but that the pressure is increasing and that it will go really fast. Also respondent EX2 thinks that the feed companies should focus more on a traceability system for the entire supply chain. *"The feed companies now have their own system and there is not much data delivered to the farmers"*. According to EX2, a traceability system for the entire chain will help to deliver guarantees about non-Genetically Modified Organism (GMO) feed for example, but also about where soy is coming from or if only certain sustainable materials are used. He said that there is a need for sharing more information with the livestock sector. Respondent EX3 mentioned that traceability can also be used in the chain for a strategic advantage. However, he mentioned that if only delivery notes are delivered to the farmers and order numbers to the suppliers, that there is no benefit.

A technology that may be can used in the future for sharing information is blockchain. Respondent FC3 said that he sees blockchain technology as a possible strategy for the future. He thinks that this could be a solution for doing things faster in the future and for sharing information in the entire supply chain. Respondent ST2 also thinks that blockchain can be a solution for products where the origin plays an important role, as the current system does not work properly. However, he thinks that it will not be used in the short-term. Respondent EX3 thinks that blockchain is not a solution for answering the problems. According to him, a blockchain does not really differ from the original systems for sharing information. He said that it is about trusting each other and a blockchain will not help, as still one of the companies has to start with sharing information. *"They always want that the other share information, but they do not want to give it themselves. This is typical Dutch"* (EX3).

4.1.5 Organisation

4.1.5.1 Quality

Quality design

All the respondents of the feed companies and their stakeholders mentioned that the quality systems are based on GMP+, which is a Dutch organisation that developed a quality system for the Dutch feed sector. The GMP+ certification is essential for delivering products. In this quality system, the regulations are included (FC6). Besides, almost all the feed companies are affiliated by SecureFeed. SecureFeed does all the risk analyses of incoming feed and controls which materials are bought per feed company (FC1, ST1, ST2).

SecureFeed and GMP+

SecureFeed started a couple of years ago in response to the horse meat scandal, as there were also too many blind spots in the feed industry, according to respondent ST2. Besides, there was too little supervision and too many companies which only researched the legally minimum (ST2). Important activities that SecureFeed is responsible for include the risk classification of products and the auditing of new suppliers. Each new supplier that wants to sell to a Dutch feed company has to be checked by SecureFeed. A feed company cannot buy from a supplier that is not on the list of SecureFeed. For products with a high risk, SecureFeed, but also the feed company of respondent FC7, go to the factories where these products are made to ensure everything is fine: *"We look at their process as if it is our process. We need to be convinced that everything is fine. The process, the monitoring, how they deal with risks"* (FC7). When there are problems with suppliers, SecureFeed goes to audit to see what happens in their factories (FC7). Additionally, each feed company has notification requirements with SecureFeed when there is something wrong with an incoming batch, where after SecureFeed spreads this information to other feed companies to ensure that it is not sold somewhere else (FC5; FC7; ST2). According to respondent ST2, the quality requirements are made in the believe that the companies want to participate. Several respondents of the feed companies stated that they try to improve the quality with the entire sector, as nobody wants a scandal again (FC2; FC4; FC5; FC7; ST1). However, according to respondent ST2, there will always be companies that will commit fraud as the temptation is too big due to money or too less supervision.

GMP+ is a quality system based on the International Organization for Standardization (ISO) quality system (ST2) and has requirements including the requirements of the law, which the feed companies have to meet (FC3; FC4; ST1; ST2). Examples are that feed companies have to trace and track within four hours (FC2; FC3; FC4; FC6; ST1), the traceability system is tested each year (FC2; FC4), that the silos are cleaned once per three months (FC2), that samples are taken (FC1; FC4; FC6), but also how a truck driver has to behave when he delivers materials (FC3). If you do not have a GMP+ certification, you are not allowed to produce feed in the Netherlands (ST1). *"The GMP+ certification is essential for delivering products. If a supplier does not have a GMP+ certification, he cannot deliver to us"* (FC4).

Respondents FC2, FC4, FC5, FC6 FC7 mentioned that they are also affiliated to other certifications such as KAT, Voederwaarde.nl, and VLOG. Moreover, each country has its own quality system (ST1), but this does not mean that you have to meet all the requirements of each quality system, as they are interchangeable. If you have a GMP+ certification, you also meet the requirements of the German quality system.

According to respondent ST2, feed companies can also make their own quality system: *"The quality systems of all the companies are similar, but they can adapt it to their system and the characteristics of their company"*.

All the feed companies have employees who are responsible for ensuring quality, varying from one employee (FC1; FC3) to an entire department that deals with quality (FC6; FC7). According to respondent FC7, the quality department is responsible for intervening when something does not go well. Attention to the quality is increasing according to respondent FC4, as his company had one employee responsible for quality at first, and now they have four employees who are responsible for the quality.

Quality control

According to almost all the respondents of the feed companies, several controls are executed to control the quality: *"Yes, for sure. Food quality is of course an important item"* (FC2). Samples are an important way to control the quality of the materials. Some of the feed companies have their own lab to do analyses, while others outsource this (ST1). Moreover, there will be checked on salmonella and other critical points in the system (FC1; FC5). Respondent ST1 mentioned that the supervision, the requirements by law, and the control of what goes into animal feed is much more strict than what goes into the food industry.

According to respondents EX2, ST2 and FC2, GMP+ and SecureFeed contribute to the controlling of the quality system. Information is shared between the feed companies and themselves to ensure the quality of materials.

Respondent FC4 mentioned that they also have their own controlling moments where colleagues of different departments go to another department, asking questions and pretending they do not know anything.

Traceability design

GMP+ also demands that tracking and tracing is possible (FC2; FC3; FC4; FC6), including how fast something is traced or how data should be recorded (FC3). Respondent FC4 mentioned that they developed the largest part of the traceability system by themselves in order to get advantages on other feed companies. According to him, most is legally demanded but in what way the feed companies develop their traceability system is up to them. The company of FC1 works together with a company which delivered their traceability system to them.

Traceability control

All the respondents of the feed companies mentioned that they test the traceability system every year with a fake recall, which is required by SecureFeed and GMP+. The test includes both tracing and tracking elements (FC6; FC7), and takes an entire day (FC3). Respondent FC6 even mentioned that they control the system twice a year for each factory, of which one is organised by SecureFeed and one by their selves. Respondent FC7 said that his feed company carries out a total of 13 tests per year in their factories, which produces 13 results that are compared with each other. The test required by SecureFeed is discussed with employees of the quality departments from about five feed companies (FC6; FC7).

Respondent PC of the premix company mentioned that it can happen that a customer complains. The premix company uses the traceability system to detect which materials are used and where they are located. In this way, the traceability system is also tested and controlled.

Traceability improvements

According to respondent PC, everything goes well when the traceability system is tested, so there is no need for improvement. Several respondents of feed companies mentioned that the audits of the traceability systems lead to improvements. Respondent FC6 and FC7 mentioned that they sometimes have to adapt the technology after a test.

Respondent FC7 also mentioned that he found out that every year, people have to do their training again. Working with traceability must be practiced, otherwise the employees will forget the procedure (FC7). *"You have to learn it again. It is the same with first aid, you have to keep practising so that when it is necessary, it can run well"* (FC7).

The companies of respondents FC1, FC3 and FC4 have a complaint system for farmers, where complains are recorded in the system. This leads in their companies to improvements of the traceability system and the quality system.

Traceability Policy

According the all the respondents, the most important goal of a traceability system is that that when something goes wrong, they can report all the information within four hours. This includes information about which materials are used, where the materials come from, and where it went to. Feed companies have detailed systems for doing this within four hours. *"This is unbelievably fast (...) When there is a problem at 19:00 o'clock, we want all the information at 23:00 o'clock"* (FC7).

According to all the feed companies, the goals of the traceability system are in line with the goals of the company: *"We want a high quality of feed, and if something goes wrong, we want to control what has happened"* (FC1). Also PC mentioned that the goals are in line with the goals of the company: *"Yes, we* *are known for our quality, and this goes together with a good working traceability system, where everything can be traced back"*.

4.1.5.2 Supply chain partnership

Trust

Seven respondents mentioned that almost all suppliers keep to the made agreements. Several respondents mentioned that there can always go something wrong, but this is not a problem as long as it does not happen too often (FC4; FC5; FC6; PC). Respondent FC4 told that they do not work with companies that do not meet the requirements, which also applies for other feed companies (FC2; FC3; FC6). According to respondent ST1, a supplier who does not meet the requirements will lose his GMP+ certification and therefore the supplier loses his market share in the Netherlands. *"The suppliers know that we check all the materials when they come in, so this prevents wrong materials from entering"* (FC5).

The reputation of suppliers is really important for all the feed companies. A supplier who had a scandal in the past, is not worked with anymore (FC1; FC3; FC4) and is usually withdrawn from the market by SecureFeed (ST1). According to respondent ST1, no feed company does business with suppliers who have a bad reputation: *"The pressure in the sector ensures that no one is doing something stupid"*. The feed companies of respondents FC1, FC4 and FC5 have long relationships with suppliers. This results in mutual trust (FC4). There are feed companies that are willing to pay more for suppliers, just because they know that the supplier can deliver the right quality (FC1; FC4).

Commitment

Some suppliers do something extra for the feed companies, like providing trainings for the feed company (FC4), delivering extra materials if necessary (FC2), providing extra or new information such as analyses (FC1; FC2; FC3; FC4; FC5; FC6), or doing research together (FC4). According to FC4, this differs per supplier. Respondents FC1 mentioned that the most important thing is the quality of the materials and not what suppliers do extra.

It is quite easy for the feed companies to change suppliers, as there are enough suppliers. When a contract ends, the feed companies are free to choose another supplier (FC1; FC2; FC4; FC5; FC6; FC7). *"you always have the choice to change the supplier"* (FC2). According to FC7, the new suppliers only have to meet the requirements of SecureFeed. Some respondents mentioned that it can be difficult to switch from supplier for certain materials as there are materials that are delivered by only a few suppliers (FC1; FC2; FC3; FC5; ST1). As relationships play an important role for feed companies, it is preferred to keep the same suppliers (ST1). Some of the feed companies mentioned that they have more suppliers for one material, which does not make them dependent on one supplier (FC4; FC7).

Communication

Suppliers and farmers are not involved in the traceability goals of the feed companies (FC1; FC2; FC3; FC6; FC7). Everyone has his own responsibility for traceability, based on the requirements of GMP+ and SecureFeed (FC6). According to respondent FC7, farmers do not have any affinity with traceability, they trust the feed companies for doing this.

Several respondents mentioned that there is enough information shared (FC1; FC2; FC5; FC6; FC7; FA1; FA2), for example analyses are sometimes delivered by the suppliers (FC1; FC6; PC). Respondent ST1 said that demands about sharing information are included in the contract between the supplier and the feed company. Respondent FC2 mentioned that if they ask for information, it is delivered by the suppliers, because they trust each other: *"It is important that we have a good relationship with our suppliers. If we trust each other, we can share information"*.

Respondent FC3 said that according to him, more information can be shared. This applies to both the famers and suppliers. Not all the farmers share the results about the meat quality or the amount of milk the cows give, which is caused by the feed they get. This is a pity according to respondent FC3 as this information can improve their products and services. Besides, the suppliers can share more information about the raw materials.

The respondents gave a different answer when questions were asked about sharing sensitive information. Several respondents mentioned that sensitive information is sometimes shared with farmers (FC2; FC5; PC; FA1). Respondent FC5 said that if a farmer has problems with his animals, information about the used materials is also shared. However, this information is only shared face-to-face and no paper with the recipe remains at the farm. This is done to prevent that the farmers show it to other feed companies.

Most of the respondents mentioned that no sensitive information is shared other than what is legally required (FC1; FC4; FC6; FC7). According to respondent FC1, it is not necessary to share more information with the farmers: *"They do not need more information. They do not even look at the printed recipe"*. According to FC7, it is not a good thing that information on traceability is shared with others, because it will go wrong. Respondents FC6 and ST1 agree that feed companies want to keep sensitive information for themselves. Respondent EX2 said that farmers do not know the composition of feed, as this is a company's secret. Even if the farmers want information, they often do not get it. This is supported by the two farmers, who stated that they can change the composition, but that they do not receive information about the exact composition of the feed they receive (FA1; FA2).

According to respondent ST1, the important aspect is who gets the data, who manages it, and what is going to happen with the data: *"if it goes so far that the farmer gets information about the suppliers and the materials of the feed companies, then there may be a sensitivity to commercial interest. A feed company does not want everyone to know where it gets its materials from"* (ST1). This is supported by respondent ST2 who stated that sharing sensitive information and how to deal with that is always an important issue. Respondents FC6 and FC7 mentioned that their company is reluctant in sharing information: *"You have to know how you deal with sharing information otherwise the transparency will be used against you. (...) It is not that you can share all the information and then you are done. It is not that someone else can manage it"* (FC7).

According to respondent ST1, other industries already share a lot of information, like the Dutch dairy industry. They are already looking for a system for the entire dairy industry which is linked to the Rijksdienst voor Ondernemend Nederland (RVO), Nederlandse Voedsel- en Warenautoriteit (NVWA), the food industry and finally the Centraal Bureau Levensmiddelenhandel (CBL), which is the branch organisation of the Dutch supermarkets. Furthermore, he told that the feed industry is not ready for sharing and connecting their data and their systems. However, he expects that this will change and that in five years all the companies in the feed sector can deliver specific data, where they all speak the same language: *"So not apples with pears, but to speak one language"* (ST1).

4.1.6 Analyses of the elements of technology and organisation

The technology that is used by the feed companies for identification and registration and administration is very suitable for traceability within the feed companies. Almost all the data is automatically captured and processed into the system, which ensures that there can be tracked and traced within four hours. However, the element 'linking' is insufficient for a chain traceability system. None of the feed companies uses software or shares databases to exchange data to suppliers or farmers.

The quality aspect of organisation is also sufficient for guaranteeing traceability within the feed companies. The quality systems and traceability systems are based on the systems and requirements of GMP+ and SecureFeed. Additionally, the quality systems and traceability systems are tested each year together with SecureFeed, which may result in improvements of the systems. Besides, goals of the traceability systems are in line with the goals of the companies themselves.

The other aspect of organisation, the supply chain partnership, shows dissimilarities. On the one hand, the relationships the feed companies have with their suppliers is good, where some feed companies already have long relationships with suppliers; suppliers almost always keep to the appointments and there are suppliers that do something extra for the feed companies. Besides, it is often easy for feed companies to change from supplier when this is necessary, which makes them independent of the suppliers.

On the other hand, suppliers and farmers are not involved in the goals of the traceability systems and the respondents of the feed companies replied differently about if sensitive information is shared with farmers. Respondents especially mentioned the negative outcomes of sharing information, causing almost no sharing of sensitive information with the suppliers. An overview of all the elements and if they meet the conditions for a traceability system is shown in table 13.

Table 13. An overview of the elements of technology and organisation that do or do not meet the conditions for a traceability system.

Elements that meet the conditions of a traceability system	Elements that do not meet the conditions of a traceability system
Identification	Linking data
Registration and Administration	Communication
Quality design	
Quality control	
Traceability design	
Traceability control	
Traceability improvement	
Traceability policy	
Trust	
Commitment	

The solutions for the CTPs and the elements that not meet the conditions

The traceability system of the feed companies and their performance can be divided into two categories: (1) within the companies and (2) for the entire chain.

The elements that affect the traceability system within the feed companies are of a high level. The required technology and arrangements are available and sufficient for capturing all the data and tracing batches back within four hours. This is the merit of the feed companies, as their production process makes it difficult to have a good working traceability system, due to the many transformations and many materials they have to work with. Their quality design and traceability design are based on the high standards of GMP+ and SecureFeed, which shows that they take the safety of their feed really seriously. However, the manual joining and weighing of mostly small materials should be avoided as much as possible since it is sensitive to errors and causes CTP 2 and CTP 3. The use of automatic devices can be a technological solution for this problem. Decisions should be made on how the physical structure of the factory should be adapted to make this possible.

At this moment, the joining of feed in the silo of the farmers is not recorded in the same way as feed companies record transformations, causing CTP 5. Recording this transformation and using a safety margin just as the feed companies do will ensure a better recording of the transformations. In case of a recall, this leads to less suspicious batches when one batch is contaminated.

The elements of technology and organisation that were insufficient for a traceability system were mainly about a traceability system for the entire chain. Traceability for the entire chain can have advantages such as guarantees about non-GMO or sustainable materials and strategic advantages. Besides, the pressure on sharing more information is increasing. This will not happen in one year, however, it will change in a couple of years.

Despite the advantages and the increasing pressure, a traceability system for the entire chain is not present: feed companies do not use technologies for linking the data, other actors within the chain are not involved in the traceability goals, and sensitive information between partners is almost never shared, which causes CTP 1 and CTP 4 (Codes are not delivered within the feed industry). Besides, data is not standardised in the chain of the feed industry. A reason for the CTPs and the lack of a traceability system for the entire chain could be that feed companies are not willing to share sensitive information because of distrust that this information will be used for other purposes than only traceability, which is mentioned by several respondents.

In order to have a traceability system for the entire chain, goals of the traceability system should be made with the actors. Besides, arrangement should be made on how and to what extent sensitive information should be shared and how exchanged data can be standardised. Communication between the suppliers, feed companies, and farmers should contribute to reducing the distrust among the feed companies in order to enhance the sharing of sensitive information. Additionally, as GMP+ and SecureFeed play an important role in the traceability design of the feed companies, they can take the lead in setting up a traceability system for the chain. By setting up such a system, the benefits a chain traceability system have can be achieved.

Table 14 shows the extra information that has to be recorded to deal with the challenges and the CTPs, compared to Table 12.

Table 14. Extra recording of data for pig feed traceability

1. Reception of raw materials
A standardised batch number is received from the supplier and linked to the received batch of raw materials
Automatically entering information about the incoming raw materials into the system
2. Storage of raw materials
The allocation of the standardised batch number to the code of the storage location
3. Weighing and dosage
Automatically weighing and dosing of all the raw materials

4. Grinding and mixing
The materials are joined and added automatically
9. Storage of end product in silo farmer
A standardised batch number of the end product is send to the farmer
10. Outflow of feed from the storage location in silo farmers
A safety margin of 30%
Recording of the sequences

4.2 Breeders

Process

According to respondent BR2, the goal of the company is to produce pigs that are more efficient each year. They work on improving the reproduction, the feed efficiency, health, welfare, and the meat and carcasses quality. This is done by a group of people that focus on synthetic genomics. Another task of the breeding company is the multiplying of pigs, which happens according to both respondents by artificial insemination. Respondent BR1 mentioned that they produce pigs on their own production location, where they have 1000 large white sows.

Information

Respondent BR1 said that they store economic related information about the pigs. Besides, information about the personal performance of the pigs is stored, such as how many there are born and how many are dying. Respondent BR2 also mentioned that they store information. At the moment a pig is born, a RFID tag is linked to the pig with information about who the mother is, who the father is, the birth date, the sex, and the company it belongs to.

Respondent BR2 mentioned that they collect as many data as possible. They work together with a group of companies where they trace pigs through the entire supply chain, until they are slaughtered. This provides a lot of information to the breeder about the slaughter quality of the pigs that are bred. This data is required to know how a set of genetics performs in practice (BR2).

Respondent EX2 said that farmers get information about the genetic line, the race, and where the pigs are coming from.

Technology

The company of respondent BR1 is investigating whether a blockchain could be used for sharing information more easily.

Both respondents mentioned that they make use of RFID tags on which information about the pig is saved. According to BR2, with this data it is possible to trace the pig back to where it is coming from.

Quality

Respondent BR1 works with two quality systems: IKB system and QS system. According to BR1, as a company you have to show that you meet the requirements and then you get a certification.

The company of respondent BR2 has three quality systems. For the research department, they have an ISO 9001 certification. The artificial insemination department has its own ISO norm system which is about the safety of processing sperm. This is an important quality system, according to BR2, as a

mistake can lead to the spread of a disease quite quickly. There is also a quality system applied for the spread of gilts. With these three systems, the company tries to ensure the safety of pigs and people.
Respondent BR2 said that they need a breeding recognition, which states that the welfare of animals is taken into account. An example given by respondent BR2 is that inbreeding is taken into account for the long term policy. However, according to BR2, breeding organisations do not have that much obligations as the feed sector has, such as ensuring that the feed is safe.
At this moment, the company of BR1 does not work with traceability yet, but he expects that traceability will play a role in the future. Also respondent BR2 mentioned that traceability is not legally required. A lot of data is collected, according to respondent BR2, which makes traceability possible at their company. According to him, traceability is getting less when a pig is sold to a farmer. This is supported by respondent BR1, who stated that the farmer does not register a lot of data. Despite the fact that it is possible to trace the pigs, they only collect data to improve the efficiency of the pigs and not for a traceability system (BR2).

Partnership

According to BR1, more information can be shared within the chain. That is why his company is investigating blockchains, to make it more transparent. Sensitive information is not shared with others (BR1).
Respondent BR2 mentioned that a lot of information is collected from the companies they work together with: *"We collect everything we can get"*.
According to respondent EX2, the farmers get sufficient information from the breeders and there are no constraints in getting this information.

Traceability within the breeding

The breeders have a totally different production process than the feed companies have. They do not have a factory where incoming materials are processed into an end product. For such a production system it is more clear what has to be traced. The breeders also do not work with materials, which makes it more logical that the breeders do not have a traceability system. As the breeders do not have a traceability system, no CTPs are identified for the breeders.
Despite not having a traceability system, a lot of important data is recorded by the breeders such as the company where it belongs to, who are the parents, the sex, the birth date, and the race. Additionally, information about the personal performance of the pigs are recorded during their lives, in order to know how a set of genetics performs. Both breeders have production systems that are based on quality systems to guarantee the safety of pigs and people.

As a lot of data is already collected about the pigs, traceability is possible at the breeders. One respondent expects that traceability in the breeding sector will play a role in the future.

5. Discussion

In this chapter, the interpretation, limitation, and suggestions for further research are provided. This study started with a literature study about food traceability. The empirical study was used to identify the CTPs and whether the elements of technology and organisation met the conditions for a traceability system. In the interpretation section, the main differences that are found are discussed. Thereafter, the limitations of this research follow. Finally, based on the interpretation and limitation, the recommendations for further research are given.

5.1 Interpretation

The results of this research gave an insight into the processes of the feed companies and breeders and the traceability systems that they use at the beginning of the pork chain. Besides, by identifying the CTPs for the Dutch pork feed companies, this study contributes to the study of Denolf (2014), where the CTPs for the pork farmers and slaughterhouses in the Netherlands were identified.

Several literature articles about food traceability define traceability as a traceability system for the entire food supply chain (Bosona & Gebresenbet, 2013; Opara, 2003). However, the most important finding of this research is that the traceability systems of the food companies are insufficient for a chain traceability system. According to this research, the pressure for a chain traceability system will increase. This is supported by Aung and Chang (2014), who stated that a traceability system for the entire chain is going to become reality, due to market forces, customer demand, and government regulations. According to the respondents, a chain traceability system will enhance benefits, which is also found in the literature. A traceability system for the entire chain allows traceability to any step in the chain, enhances the standardisation, and improves the efficiency and speed of a recall when safety standards are breached (Anne-Marie Donnelly et al., 2012; Aung & Chang, 2014).

An important aspect of chain traceability is standardisation of exchanged data. In the literature review, it has been found that standardisation is lacking in food supply chains, which makes it complicated to share information. This is also confirmed in this study, where codes are not shared in the feed industry and each feed company uses different codes for its products. Respondents mentioned that the need for sharing information is increasing, but that the feed industry should speak the same language first.

Furthermore, several respondents mentioned that sensitive information is not shared between the partners and that they want to keep this information for themselves. This is also found by Donnelly and Olsen (2012), who stated that the most common problem in chain traceability is data protection and privacy.

A way to deal with sharing sensitive information is blockchain. Blockchain is mentioned by respondents of the feed industry as well as the breeders for sharing data more easily. However, one respondent said that blockchain will not be a solution as actors in the chain still need to trust each other. According to

Abeyratne and Monfared (2016), the blockchain technology is more secure and transparent than the existing systems of sharing information. Additionally, a blockchain can allow customers to access data about a product that has been manufactured in a supply chain, allowing them to make better choices.

In order to reduce the CTPs, this research suggests that technology should be used for linking the data in the chain and to reduce manual action. It is possible to use technology for this, as there are already examples that technology is being used for solving this problems in other industries, such as the dairy industry. However, according to Bosona and Gebresenbet (2013), developing and implementing traceability for an entire chain is expensive and can lead to financial problems. Additionally, dividing the costs and benefits among the actors in the chain needs extra cost and effort. It may lead to resistance of some partners. Especially small companies may experience cost disadvantages compared to medium and large sized companies. In the case of the feed industry, this means that farmers have more cost disadvantages compared to the suppliers and feed companies. However, Aung and Chang (2014) mentioned that for high-risk and high-valued food, the benefits of an efficient traceability system outweigh the cost of traceability.

This study found that manual action is influencing the traceability system in a negative way as it may cause errors. Therefore, the use of manual action should be avoided as much as possible when companies work with traceability. Literature about food traceability does not mention what the influence of manual action is on the traceability systems. However, this study shows that it is important and that companies should take it into account when implementing a traceability system.

5.2 Limitations

This research has several limitations that are worth noticing. Firstly, for a more detailed view of the feed industry, ideally traders of raw materials also need to be interviewed to find out how traceability plays a role at the beginning of the feed industry. However due to limitations of time and the choice for already studying two sectors (breeders and feed companies), this was not possible.

Secondly, the four components used in this research are also related to each other. For example: the level of supply chain partnership and the level of technology for linking data both affect the information exchange among the actors in the chain. Additionally, also elements of the component organisation are related to each other, as both trust and communication influence the amount of information that is shared. Another relation is between data capturing and the process flow. During the storage, production process, and transformation, information should be kept and exchanged. However, the underlying relationships are not investigated in this research. It would be difficult to map the complete set of relationships, as there are four components used in this research, each having multiple elements.

Thirdly, the objective of this research is to identify the CTPs and whether the elements of technology and organisation meet the conditions for a traceability system for the feed companies and breeders. However, the breeders do not have a traceability system, making it impossible to identify CTPs and to know if the elements of organisation and technology are sufficient for a traceability system for the breeders.

Lastly, the different elements of the components used in this report can be extended. For example: within the element of supply chain partnership, power could also play a role.

5.3 Recommendations for further research

From both the literature study as well as the this study, it has been found that data protection and privacy are important issues for a traceability system in the chain. However, information about how this problem can be overcome is lacking. Further research can be important for industries that want to implement chain traceability, as it is still a barrier for the feed companies to share sensitive information. Blockchain may reduce this barrier, however the blockchain technology is still new, and is mainly used for digital currencies. According to Abeyratne and Monfared (2016), blockchain can also be used in manufacturing supply chains. However, case studies are lacking because blockchain is a recent technology. More research needs to be conducted to find the barriers and drivers for implementing a blockchain.

Secondly, the standardisation is lacking within the feed industry and according to the literature it is also lacking in other food industries. A solution for this is a standardised data terminology for the entire sector. In the feed industry, such a standardised data terminology can contribute to the implementation of a chain traceability. GMP+ and SecureFeed play an important role in the development of the quality and traceability systems, and they may contribute to a standardised data terminology. Further research can study how this can be implemented within the feed industry.

The last suggestion for further research is the influence of manual actions. Manual actions take place in the feed industry, affecting the precision of the traceability systems, according to the respondents. Evidence about the influence of manual actions on the traceability system is limited. As this study shows the impact of manual action, it is interesting to study to what extent manual action influences traceability. This will ensure that companies that implement traceability take this into account.

6. Conclusion

Traceability studies and the horse meat scandal showed that there are still gaps in traceability systems. In this research, the traceability systems within breeders and feed companies were investigated. This study aimed to identify the Critical Traceability Points (CTPs) for the feed companies within the Dutch pork supply chain, and to examine whether the elements of technology and organisation of both actors meet the conditions for a traceability system.

The CTPs are identified based on the analyses of the process and information flow between the suppliers, feed companies, and farmers. For the feed companies, five critical traceability points (CTPs) were identified, where information may get lost. At the CTPs 1 and 4 codes were not shared between the different actors in the chain, at CTPs 2 and 3, human action took place, and CTP 5 was caused because transformations in the silo of the farmers were not recorded.

Then, the different elements of technology and organisation were analysed, to find out whether these elements met the conditions for a traceability system. In general, the elements of technology and organisation are very suitable for a traceability system within the feed companies. The elements that are not sufficient for a traceability system were linking data and communication.

These two analyses performed in this research showed that the traceability systems of the feed companies are of a high level. The many transformations of the materials they work with make it difficult to have a well working traceability system. However, only a couple of CTPs were identified and only two elements of technology and organisation did not meet the conditions for a traceability system.

In order to improve the traceability even more, a few changes have to be made. Technology has to be implemented to get rid of manual action. Besides, arrangements should be made with the suppliers and farmers how information can be shared in the chain. The focus should be on the element communication in order to decrease distrust and to enhance the sharing of information. Additionally, technology for sharing data should be implemented. Blockchain might be a useful technology for this in the future. It is important that these suggested improvements are taken seriously by the actors in the feed chain, as the pressure for sharing information within the feed industry will increase.

This study also investigated traceability within the breeders. The CTPs are not identified for the breeders, because they do not have traceability systems. However, a lot of data is saved and devices are used such as RFID tags. The breeders also have to meet the requirements of certain quality system to guarantee the safety of pigs and people. So, as a lot of data is already collected, traceability is possible for the breeders.

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Appendix 1. Example of an e-mail sent to a feed company in Dutch

Beste heer/mevrouw,

Voor het afstuderen aan de Wageningen University & Research doe ik onderzoek naar hoe de traceerbaarheid in de keten van de varkensindustrie verbeterd kan worden. Hierbij ligt de focus op het begin van de keten, zoals de veevoer sector en de fokkerij sector.

De focus ligt hierbij op de vier punten van traceability: de proces flow (productieproces en materiaal flow), de informatie flow, de technologie die gebruikt wordt voor het traceability systeem en hoe het traceability systeem wordt georganiseerd, zowel binnen het bedrijf zelf als tussen bedrijven. De vragen in het interview zullen hier dan ook over gaan.

Omdat uw organisatie, [Bedrijfsnaam], veevoer maakt, zou ik u willen vragen of u of één van uw medewerkers op dit gebied tijd heeft voor een kort interview. Ik benader u voor een onderzoek zonder commerciële doeleinden. Informatie en gegevens die worden gebruikt zullen vanzelfsprekend in vertrouwen behandeld worden. Indien gewenst kunnen hierover schriftelijk afspraken worden gemaakt.

Ik zou u graag over een paar dagen willen bellen om te vragen of u bereid bent om mee te werken aan mijn onderzoek.

Alvast bedankt voor uw tijd.
Met vriendelijke groet,

Ties van Noorden
0627328217
Master student Management, Economics and Consumer studies
Wageningen University and Research

Appendix 2. Interview guide

- *Bedanken voor tijd nemen en formeel voorstellen*
- *Uitleggen doel van het onderzoek en waarvoor we dit onderzoek doen (wageningen Universiteit, afstudeerthesis)*
- *Doel van het interview: "U heeft kennis van veevoer en de daarbij horende traceability". Dit interview gaat over de materiaal stroom, welke informatie er wordt opgeslagen, de technologieën die hiervoor gebruikt worden en hoe dit georganiseerd wordt.*
- *Vertel dat interview maximaal één uur zal duren*
- *Noemen dat alle antwoorden worden verwerkt in het verslag met de naam van het bedrijf en de functie, maar niet met naam als dit niet op prijs wordt gesteld.*
- *Vragen of het in orde is dat geluidsopname wordt gemaakt en vertel dat de geluidsopname wordt verwijderd na het uitwerken van de tekst*
- *Heeft u nog vragen of zijn er nog onduidelijkheden voordat we beginnen?*

[Name Interview] [Functie] Ties van Noorden [Date] Location: Duration:

Interviewvragen

Intro

Zou u een korte omschrijving willen geven van uw functie binnen [Bedrijf]?

Proces en informatie vragen

Proces

ontvangst

- Er worden veel grondstoffen aan jullie geleverd door jullie leveranciers, zoals: Gerst, tarwe, graan, mais (bij producten van de levelsmiddelenindustrie), sojaschroot, zonneschroot, raapzaadschilfers, palmpitschilfers, premixen, vloeistoffen zoals vismeel, zout, enzymen.
  Waar komen de materialen die gebruikt worden voor het produceren van mengvoer vandaan?
- Wordt iedere grondstof door een leveranciers geleverd of kan het ook zo zijn dat er meerdere leveranciers zijn voor een bepaalde grondstof?
- Hoe vaak worden de verschillende materialen aangeleverd?
- Worden materialen bij elkaar gevoegd of gesplitst door de leverancier? Zo ja, welke materialen zijn dat?

productie

- Hoe verloopt het productieproces? (*pak tekening erbij*)
- *Worden materialen bij elkaar gevoegd of gesplitst die uw bedrijf ontvangt? Zo ja, welke materialen zijn dat?*
- Worden materialen bij elkaar gevoegd of gesplitst tijdens de productie?
- Worden er producten tijdens het proces tussentijds opgeslagen of loopt het proces in een keer door?
- Worden alle materialen gewogen voordat ze gebruikt worden in het productieproces? Wat gebeurd er bijvoorbeeld met goedkope materialen?
- Hoe worden premixen en vloeistoffen tijdens het mengen toegevoegd? Wordt dit ook afgewogen?
- Waarschijnlijk zijn er verschillende productieprocessen mogelijk en verschillende samenstellingen van het veevoer, hoe heeft dit invloed op de traceability?
- Als het product klaar is, worden er dan samples genomen?

Informatie

<u>Ontvangst</u>

- Welke gegevens worden er allemaal opgeslagen bij het ontvangen van materialen per toeleverancier?
- Worden er door de toeleverancier unieke codes voor de materialen aangeleverd? Verschilt dit per toeleverancier?
- Meestal gebeurt het tracen naar de leveranciers doormiddel van het losnummer, wat gebeurt er als die kwijt is?

<u>Storage</u>

- Wat gebeurd er als er meerdere materialen in een silo worden opgeslagen? En hoe wordt de informatie hierover opgeslagen?
- Heeft iedere silo een eigen unieke code?
- Wordt de volgorde van de materialenstroom in de silo bijgehouden?
- Worden silo's tijdelijk geleegd en schoongemaakt?
- Hoe wordt de uitstroom van de premixen en vloeistoffen gekoppeld aan het product?

<u>productie</u>

- Wat voor informatie wordt er opgeslagen tijdens de productie?
- Wat wordt er gezien als 1 batch? (tijdframes, 1 productierun, een pallet? Samples?)

<u>Levering</u>

- Hoe wordt de veevoer afgeleverd aan de boer?
- Worden er documenten meegestuurd naar de klant?
- Bewaard de boer deze gegevens?

<u>Technologie vragen</u>

Identification of data

- Hoe worden de batches gelabeld *(barcode, RFID-tag, tekstueel code)*
- Hoe wordt de informatie van inkomende batches in het systeem opgenomen? (dus bijvoorbeeld: de batch heeft een bepaald gewicht, hoe wordt dit in het systeem van de veevoerhouders opgenomen?

Registratie

- (Hoe wordt data van inkomende materialen geregistreerd? *(RFID, Barcode))*
- Wordt er gebruik gemaakt van barcodes of RFID tags?

- (Waarom is er hiervoor gekozen?)

Data processing

- Welke data verwerkingssystemen worden er gebruikt voor het traceerbaarheid systeem? (ERP, MES)
- Wat zijn de voordelen en nadelen van dit systeem?

Communiceren van de data

- Wat voor technologieën worden er gebruikt om data door te geven in de keten?
- (Waarom is er voor dit systeem gekozen?)
- Hebben de partijen in de keten een gezamenlijke database, of heeft iedereen zijn eigen database?

Organisatie vragen

Algemeen:

- Hoe werkt jullie kwaliteitssysteem? (Quality design)
- Hebben jullie daarvoor iemand lopen die dit als functie heeft?
- Hebben jullie controle punten in het proces? (Quality control

Managerial functies

- ((Is het traceability systeem dat aanwezig is, van te voren ontworpen? (*Traceability design*)))
- Wat voor doelen zijn er gesteld aan het traceability systeem? (*Traceability design*)
- Worden er eisen gesteld aan de mensen die met het traceability systeem werken? Zo ja, wat voor eisen dan? (*Traceability design*)
- Welke controle stappen vinden plaats om traceability op orde te houden? (*Traceability control)*
- Hoe komen jullie tot kwaliteitsverbeteringen van jullie traceability systeem? (*Traceability improvement*)
- Zijn de doelen van het traceability systeem in lijn met de doelen van uw bedrijf? (*Traceability policy & strategy*)

Partnerschap
Vertrouwen

- Houden de leveranciers en klanten zich aan de gemaakte afspraken?
  Zo ja, zijn er uitzonderingen?
  Zo nee, wie niet en waarom niet?
  (*Predictable behaviour*)
- Wordt er volgens u voldoende informatie gedeeld tussen u en uw klanten en u en uw leveranciers?
  Met wie wel en met wie niet? (*information sharing)*
- ((*Zijn de voordelen van een overeenkomsten tussen uw bedrijf en leveranciers en klanten bekend? (satisfaction[lijkt op shared value])))*
- Kijkt u naar de reputatie van een leverancier of klant voordat u bedrijf zaken met hen doet?
  Bij welke leveranciers houdt u hier meer rekeningen mee? (*reputation*)
- Weten u en uw partners beide wat belangrijk is voor elkaar? (*shared value* [ook voor inzet*]*)

Inzet

- Doet de leveranciers of de klant wel is iets extra's voor uw bedrijf? En andersom?
  Welke leveranciers zijn dit? (*adaption)*
- Is het makkelijk om van leverancier of klant te wisselen?
  Bij welke leveranciers is dit makkelijk, bij welke moeilijk? (*relationship termination costs*)

Communicatie

- *(Is de informatie volledig die tussen u bedrijf en uw klanten en uw bedrijf en leveranciers wordt uitgewisseld? Zit daar verschil tussen? (Communication quality))*
- Worden partners betrokken bij het maken van goals en planning? Zo ja, welke partners? (*Planning and goal setting*)
- Worden partners betrokken bij het maken van goals en planning voor de traceability systemen? Zo ja, welke partners? (*Planning and goal setting*)
- Wordt er gevoelige informatie uitgewisseld tussen u en uw partners?
  Met welke partners deelt u gevoelige informatie? (*Sensitive information*)

Laatste vraag

- Wat zijn de belangrijkste uitdagingen van een traceability systeem?
- Als het traceability systeem niet helemaal naar behoren werkt, waar zitten dan de fouten?

Afsluitende vraag:

- Is er nog informatie die u wilt vertellen of zijn we nog iets belangrijks vergeten te vragen?
- Vragen naar de mogelijkheid om een klant (een boer) ook te mogen interviewen

Eind van het interview

- *Bedanken voor de tijd en antwoorden.*
- *Zijn er nog vragen of onduidelijkheden?*
- *Weet de ondervraagde wellicht nog interessante stukken die voorgaande vragen of daarom verwante vragen goed zouden kunnen beantwoorden? Of is de ondervraagde in het bezit van dergelijke stukken? Deze documenten zullen niet gedeeld worden en vertrouwelijk behandeld worden.*
- Mijn mail geven indien nodig: Ties.vannoorden@wur.nl

Vragen of ze geïnteresseerd zijn in het ontvangen van het rapport en de presentatie