UNIVERSITY OF GOTHENBURG
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Master Degree Project in Logistics and Transport Management

Would You Care for a Warm Steak?

An evaluation of time-temperature indicators to ensure quality and enhance sustainability in Swedish meat supply chains

Moa Gustafsson and Mikaela Sundström

Supervisor: Michael Browne
Master Degree Project
Graduate School

Abstract

In recent years, scandals and disruptions in food supply chains have generated an increased pressure on actors to ensure quality and traceability, as well as to improve sustainability. The absence of constant temperature control in the supply chain endangers consumer safety and contributes to the sustainability issue of food wastage. For grocery retailers, it is essential to guarantee food quality from farm to fork, especially for highly sensitive products; however, this cannot be fully achieved today. A time-temperature indicator (TTI) is a traceability solution that can be utilised by supply chain actors to track temperature along the chain; thus, can facilitate improved control and ensure food quality. It is evident that theory lacks extensive knowledge regarding the expected benefits and risks associated with an application of TTIs, as well as how to efficiently implement the technology. Therefore, the purpose of this thesis is to provide an assessment that can serve as a guide for a future potential implementation of TTIs in a Swedish meat supply chain to enhance traceability and improve sustainability. To fulfil the purpose, a single case study was conducted at Coop in Solna where 15 interviews were held with actors representing their entire supply chain. In addition, a focus group interview was performed to gather the views and opinions of consumers. The result of the study indicates that there are various benefits and risk associated with a potential implementation. Additionally, these are highly dependent on the aim of the implementation. Furthermore, depending on the objective of the initiative, various benefits and risks needs to be taken in consideration for an efficient implementation. The findings have contributed to broaden the existing knowledge of how traceability systems such as TTIs can be used to improve quality and sustainability performance.

Keywords: chain traceability, sustainability, time-temperature indicators, implementation, meat supply chain, intelligent packaging, food wastage

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Mikaela Sundström Moa Gustafsson

List of abbreviations

CCM	cold chain management
GHG	greenhouse gas
IP	intelligent packaging
SCM	supply chain management
TBL	triple bottom line
TTI	time temperature indicator

Table of Content

Index of tables

Index of figures

1. Introduction

This section introduces the topic of traceability and sustainability within the context of food supply chains, which is followed by a presentation of the identified problem. The problem description laid the foundation for this study, which culminated in the purpose of the thesis together with the associated research questions. The delimitations and disposition of the thesis conclude this section.

1.1 Background description

Over the past years, actors within the food sector have experienced growing pressure to guarantee efficient supply chains and improve traceability. Disruptions in food supply chains, such as the highly scrutinised horse meat scandal in Europe, 2013 (Ringsberg, 2014) and the lack of quality control in the Brazilian meat industry in 2017 (Brooks & Patton, 2017), have generated increasing societal awareness of traceability issues and highlighted inadequacies within the industry (Meuwissen, Velthuis, Hogeveen & Huirne, 2003). Hence, pressure is arising from several stakeholders, such as independent organisations, governing bodies, and the society as a whole, encouraging corporations to improve their current practices (Fritz & Scheifer, 2008; Seuring & Müller, 2008; Scheifer, 2002) and restore consumer confidence (Sarpong, 2014).

Today, actors in supply chains are reliant on the next link; thus, their responsibility is primarily focused on their own operations in isolation rather than assuring the prosperity of the entire chain (Olsson & Skjöldebrand, 2008). Additionally, as a result of globalisation, extended trading chains are emerging, which bring complexity and risk of first rank (Aung & Chang, 2014). For food in particular, the perishable and sensitive nature, seasonality in demand and supply, and the health and safety considerations inherent to the management of food products entail additional challenges for logistics management (van der Vorst & Beulens, 2002). Thus, food supply chain actors are dependent on each other due to the perishability of the products and the strict quality and traceability legislations (Fredriksson & Liljestrand, 2015). Moreover, due to the increasing importance of food logistics and demands for logistical solutions adapted to the specific needs of the food industry, further research is needed (Fredriksson & Liljestrand, 2015).

Additional challenges of food logistics are sustainability related issues, in particular the issue of food wastage being generated throughout the chain. In 2012, Swedish businesses, restaurants and households threw away 1.2 million tonnes of food, out of which nearly half of the amount was unnecessary waste (Naturvårdsverket, 2014). Consequently, by proactively enhancing traceability and control in food supply chains through the development of new techniques and innovations, unnecessary food wastage can be prevented (Olsson & Skjöldebrand, 2008). Hence, traceability is to be considered beneficial for various reasons

ranging from preventing and following up on disruptions in food safety to promote sustainable consumption.

Although traceability tools are applied in food supply chains many of the solutions currently in use, including batch numbers and EAN barcodes, lack a holistic utilisation and quality monitoring of the individual product. An alternative to these tools are time-temperature indicators (TTIs) which possess the ability to monitor and record temperature and/or shelf life along each stage in the chain for chilled and frozen food products; thus, can be utilised to increase traceability (Kreyenschmidt, Christiansen, Hübner, Raab & Petersen, 2010; Taoukis & Labuza, 1989). However, the technology is yet to be extensively implemented in food supply chains (Raab, Petersen & Kreyenschmidt, 2011) and has currently not yet been applied on the Swedish market.

1.2 Problem description

Although the term 'traceability' is not new in academia, research as of understanding its deeper meaning is lacking and knowledge about traceability systems is likewise insufficient; hence, researchers are inquiring further examinations (e.g. Aung & Chang, 2014; Karlsen, Dreyer, Olsen & Elvevoll, 2013; Sahin, Zied Babaï, Dallery & Vaillant, 2007). For retailers, the lack of knowledge is especially severe as consumers are holding them responsible for scandals connected to the upstream and downstream flows, as retailers often rule or govern their supply chains (Seuring & Müller, 2008). Additionally, firms are required by the EC (178/2002) to track and trace products through the chain, as well as to ensure the quality and safety of their products. In the future, the issue of managing efficient traceability systems will become even more important as control and traceability in the supply chain are predicted to be prerequisites for firm success and to achieve competitive advantage in the long run (Aung & Chang, 2014). Moreover, the demands for food quality and traceability are becoming stricter; thus, a proactive approach by businesses could reap significant benefits in the future.

During the last decade, the food sector, in particular the meat production has been significantly scrutinised from all quarters due to its environmental impact (e.g. Jordbruksverket, 2013; Belz & Peattie, 2012; Fiala, 2008). Among these considerations is food wastage, which has received substantial attention in recent years (e.g. Verghese, Lewis, Lockrey & Williams, 2015; Kummu, de Moel, FPorkka, Siebert, Varis & Ward, 2012; Parfitt, Barthel & Macnaughton, 2010). In 2012, the estimated food wastage in the European Union (EU) was 88 million tonnes, which corresponds to 20% of all the food produced in EU during that year (Stenmarck, Jensen, Quested & Moates, 2016). This implies that a part of the food produced is redundant, even though some wastage is unavoidable. Moreover, the food wastage in the EU countries generated a financial loss of €143 billion in 2012. As wastage is generated through the entire chain, where households account for the largest share (53%), the economic loss affects both corporations and consumers (Stenmarck et al., 2016). To deal with sustainability issues, integration and collaboration between actors in the chain are required in

order to connect economic, social and environmental issues to management decisions (Schiefer, 2002). Hence, to enhance sustainability, integration and traceability throughout the whole supply chain is a necessity. However, research within the fields of food supply chains and traceability have rarely been examined further down the chain than to the point of sale. Hence, ignoring the consumer stage.

Currently, technological developments have contributed with several tools facilitating traceability and control within chains, as well as improved food quality and inventory management (Sahin et al., 2007). In contrast, there is limited knowledge regarding decision-making and implementation of novel traceability technologies, whereas existing research in this area is concentrated on the technological aspects of these innovations. Additionally, a linkage to practice is missing, particularly when looking at the Swedish food industry as these innovations have not yet been implemented. Similarly, research explicitly request case studies on future users of these technologies to complement existing knowledge and generate in-depth understanding of the field (Sahin et al., 2007).

In conclusion, the majority of research examining traceability within supply chains ends at the point of retail, and knowledge concerning efficient traceability tools and their implementation are missing. Consequently, the absence of a holistic view and a responsibility permeating the entire chain increase the risks of supply chain disruption, which endanger consumer safety and ignore a large contributor to the sustainability issue of food wastage.

1.3 Purpose & Research question

The purpose of the thesis is to provide an assessment that can serve as a guide for a future potential implementation of time-temperature indicators in Swedish meat supply chains. More specifically, serve as an initial evaluation that can act as a foundation for decision-making regarding implementation of a technological innovation to enhance traceability and improve sustainability. In order to fulfil the purpose, the following research questions have been formulated:

1. *What are the benefits and risks associated with implementing time-temperature indicators in Swedish meat supply chains from a retailer perspective?*

2. *How can time-temperature indicators be efficiently implemented in Swedish meat supply chains?*

An efficient implementation is defined as overall advantageous for the retailer in the long-term, and generate mainly positive effects on traceability, sustainability, food quality and safety, and brand reputation. By exploring the benefits and risks as well as the approach of applying time-temperature indicators in meat supply chains, this thesis seeks to broaden firms' and researchers' knowledge and understanding regarding an implementation of

traceability systems. Furthermore, the study provides practical insights to establish a more comprehensive view of traceability in food supply chains, as it is vital to consider all actors involved to strengthen quality and control. While this thesis may not have complete generalisability, it can be argued to contribute with relevant insights for the industry. This is due to the high concentration of the Swedish grocery industry (Eriksson, Pano & Ghosh, 2016) and that the Swedish grocery retailer chains share similar characteristics. Finally, a contribution to theory is made as the study promotes understanding of the distribution of benefits and risks associated with an implementation using a business case.

1.4 Delimitation

To clarify the boundaries of the study, several delimitations have been made. First, the emphasis is on Swedish food supply chains; hence, solely regulations and legislations within EU and Sweden will be considered. Furthermore, the thesis will only scrutinise the chilled meat supply chain, more specifically pork and beef products, produced for Coop's store brand and sold at physical stores. Hence, trade connected to e-commerce is not treated in this thesis. Likewise, the thesis exclusively focuses on the sustainability issue of food wastage from production up to the point of consumption. Therefore, the thesis will not attempt to scrutinise sustainability concerns such as deforestation, water usage and emissions. Moreover, the thesis focuses on two different TTIs and therefore leave out other indicators and technologies. Since TTIs have not been implemented in a Swedish supply chain at the time of writing this thesis, the research investigates the expected benefits and risks with an implementation. Finally, the focus will be on the identification of benefits and risks; thus, this study will not be quantifying the variables in terms of cost.

1.5 Disposition

Following the introduction, section 2 presents a literature review which explores and discusses previous research relevant to the field, functioning as a base for the construction of the interview guides. Section 3 introduces the methodology, which explains and provides the rationale for the research approach and design, as well as the selected method and sample. The section concludes with a description of the analytical process and qualitative assessments made. The case description is given in section 4 where more detailed information about the Swedish food industry and the chosen company of investigation are supplied. Subsequently, section 5 presents the empirical findings gathered through data collection. The findings are analysed and discussed in relation to previous research, which is compiled in section 6. Conclusions of the study and practical implications are provided in section 7. The section is concluded by discussing limitations and suggestions for future research.

2. Literature review

The literature review is structured around three main headings; food supply chains and their increasing complexity, food quality and food safety addressing the risks of food logistics as well as emphasising the importance of traceability, and finally the critical role of packaging innovations for enhancing traceability and sustainability. Finally, the key arguments of the review are summarised in section 2.4. The literature review has further been used as a framework that formed the questions and the structure of the interview guides.

2.1 Food supply chain

Supply chains and supply chain management (SCM) have been scrutinised for over 30 years (Oliver & Weber, 1982). Thereafter the concept has evolved considerably from being viewed as external logistics of a company (e.g. Lee & Billington, 1992) to now include suppliers and customers where the focus is on cross-functional integration and competition on a supply chain level (Lambert & Cooper, 2000). The SCM view has progressed into several different streams of research related to supply chains and their management creating a broad area of investigation (Ellram & Cooper, 2014), covering topics including logistics, marketing (Lambert & Cooper, 2000), manufacturing, customer management (Ross, 1998), purchasing (Burgess, Singh & Koroglu, 2006), and information management (Breite & Vanharanta, 2004). Supply chains are networks encompassing several parties including producers, transporters, distributors, and retailers, which bring products or services from a source to a customer through the upstream and downstream flow of materials, information and finances (Seuring & Müller, 2008; Simchi-Levi, Kaminsky & Simchi-Levi, 2004; Mentzer, DeWitt, Keebler, Min, Nix, Smith & Zacharia, 2001).

As the subject covers many issues and ideas for improving chain performance there are many definitions of SCM and, consequently, confusion regarding its meaning (Olsson & Skjöldebrand, 2008; Burgess et al., 2006; Mentzer et al., 2001). In a literature review of 100 SCM articles made by Burgess et al. (2006) over half completely lacked a definition of the term. To create a common understanding of SCM, multiple researchers have attempted to create a general definition (e.g. Lummus, Krumwiede & Vokurka, 2001; Mentzer et al., 2001). The definition used in this paper is provided by Simchi-Levi, Kaminsky and Simchi-Levi who define it as "*...a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize systemwide costs while satisfying service level requirements*" (2008, p. 1).

Similar to the general concept of supply chains, a *food* supply chain involves multiple actors, including consumers, retailers and food services, wholesalers, transporters, manufacturers and agriculture (Olsson & Skjöldebrand, 2008) bringing products to the market from raw material to consumed product (Dani, 2015; Fritz & Schiefer, 2008). However, researchers

argue that food supply chains are more complex and challenging to manage compared to the majority of product supply chains due to the perishable nature of the products (Fredriksson & Liljestrand, 2015; Aung & Chang, 2014). The inherent importance of product quality in supply chains (Luning & Marcelis, 2006) makes controlling and ensuring food quality essential for the performance of food supply chains (van der Vorst, Tromp & van der Zee, 2009). Furthermore, there are multiple characteristics of the products, especially perishable products, that influence the food supply chain including seasonality, global sourcing, variations in yields, quality constraints, tailored transportation, and traceability requirements (Bourlakis & Weightman, 2004).

Food supply chains are further challenged by the population and environmental pressures (Kummu et al., 2012), as well as the developments towards globalisation, which generate increasingly complex chains with longer distances between raw materials, production and stores (Olsson & Skjöldebrand, 2008). Van der Vorst et al. (2009) argue that multiple supply chains and businesses can be identified within food supply chain networks, thus resulting in various roles of organisations depending on the specific chain setting. Consequently, organisations can be competitors in one setting, while being partners in another. Ultimately, researchers argue that integration and coordination between actors is vital to successfully manage the supply chain (Lambert & Cooper, 2000; Lummus & Vokurka, 1999) and adhere to quality requirements of perishable food products (van der Vorst et al., 2009).

Although the subject of supply chain management has developed into including suppliers and consumers, a holistic view and a responsibility for the whole supply chain are lacking among businesses (Olsson & Skjöldebrand, 2008). Thus, there is a need for consideration of longer parts of the chain to account for a wider range of risks (Seuring & Müller, 2008). Retailers are increasingly held accountable for supply chain concerns from raw material to consumers (Seuring & Müller, 2008). However, the consumer segment of the chain is often left out when businesses and academics consider issues of food supply chain management (Aung & Chang, 2014; Raab et al., 2011) despite that consumers often are a weak point in the chain of perishable food products (Schmidt, Lettmann & Stamminger, 2010; Olsson & Skjöldebrand, 2008). The consumers often lack knowledge regarding proper temperature handling and the food products may be exposed to variations in temperature during transport to the household as well as incorrect storage conditions at the home location (Olsson & Skjöldebrand, 2008). Hence, researchers are increasingly recognising consumer inclusion as imperative for food supply chain success. Olsson and Skjöldebrand (2008) claim that consumer insights provide valuable knowledge for meeting consumer demands. Moreover, issues of traceability and food quality are often not considered once the products leave the store, hence, are uncontrolled at the consumer location compromising food and consumer safety (Mazini & Accorsi, 2013). Thus, literature increasingly emphasises the necessity for practitioners to extend the supply chain view to include the consumer segment.

2.1.1 Cold chain management

Cold chain management (CCM) is "*...the process of planning, implementing and controlling efficient, effective flow and storage of perishable goods, related services and information from one or more points of origin to the points of production, distribution and consumptions in order to meet customers' requirements on a worldwide scale*" (Bogataj, Bogataj & Vodopivec, 2005, p. 346). Effective management of the cold chain facilitates control of quality and quantity during the entire chain (Aung & Chang, 2014), which is essential to ensure food quality and consumer safety (Kreyenschmidt et al., 2010).

To maintain control of the entire supply chain and minimise the possibility of breaks in the cold chain risk assessment is imperative (Bogataj et al., 2005). For perishable products, temperature is commonly argued to be a significant influencer on product degradation (e.g. Aung & Chang, 2014; van der Vorst et al., 2009; Olsson & Skjöldebrand, 2008; Taoukis, Koutsoumanis & Nychas, 1999). Consequently, the temperature during each stage of the chain needs to be monitored and controlled (Raab et al., 2011; Bogataj et al., 2005; Taoukis et al, 1999). A study by Bogataj et al. (2005) argued that visibility and proper control throughout the cold chain are fundamental for efficient management. This view of components essential for successful cold chain management is likewise shared by Raab et al. (2011) suggesting that inter-organisational collaboration, efficient information management and temperature control are prerequisites for financial success and cold chain performance.

2.1.2 Sustainable supply chain management

Historically, sustainability has been connected to resource usage, in terms of natural, human and financial aspects, with emphasis on the ability to continue with the current rate of consumption indefinitely (Marinova & Raven, 2006). During the 1970s, sustainability was associated with the equal distribution and use of resources. This was followed by the release of the famous Brundtland report in 1987 stating the most common definition of sustainable development (Marinova & Raven, 2006). The Brundtland report defines the concept as a development that "*meets the needs of the present without compromising the ability of future generations to meet their needs*" (World Commission on Environment and Development, 1987, p.43). However, sustainability has various comprehensions with one of the most central being the triple bottom line (TBL) given by Elkington (1997), which will be referred to when discussing sustainability in this thesis. The TBL seeks to extend the focus within firms from solely being financial to also include social and environmental responsibilities (Elkington, 1997).

The topic of sustainable supply chain management is relatively novel with few studies conducted in the subject up to the beginning of the 21st century (Gold, Seuring & Beske, 2010). Yet, the recent growth in attention and importance of sustainability has resulted in a significant increase in research activity connected to sustainability in relation to supply chain management during recent years (Pagell & Shevchenko, 2014). Similarly, the TBL

established by Elkington (1997) can now be seen to permeate many firms as management activities are getting extended from exclusively being financially focused to also include social and environmental aspects (Scheifer, 2002). During each stage of production, there are social and environmental effects embedded in the chain, which are increasingly being considered among firms in their daily operations (Seuring & Müller, 2008). Scheifer (2002) claims that this change is due to pressure from several interest groups with different objectives surrounding firms, which all needs to be considered by the firm itself. To address these objectives, Scheifer (2002) suggests that firms can apply the concept 'integrated process management', which involves dividing management activities into three categories. These categories are: business management activities focusing on economic aspects, quality management activities emphasising consumer's quality interests concerning products and services, and environmental management activities targeting society's environmental sustainability interest.

According to Scheifer (2002), focusing on the meat industry specifically, there are extensive research to be done in terms of TBL and adapting integrated process management, and how to manage various interests of external groups, as it is a rather complex issue. Currently, the industry is negatively associated with environmental sustainability issues, which needs to be addressed with urgency due to its damaging effects on the environment. Yet, it should not exclusively be criticised as there are countries dependent on it from a social and economic perspective (Steinfelt, Gerber, Wassenaar, Castel & de Haan, 2006). In the future, sustainability concerns in the food industry will likely become even more scrutinised and receive significant attention in research as growing attention is now targeted towards overconsumption and food wastage.

2.1.3 Food wastage

The issue of food wastage has gained attention in recent years as the focus on sustainability has increased. However, food wastage is not new to the market. The first response to this issue came during the 1970s where reduction in food wastage was deemed as part of a potential solution to solve world hunger (Parfitt et al., 2010). Today, the view on food wastage has become more holistic and is present on the global agenda due to the rapid depletion of natural resources. Expectedly, the issue of food wastage has been increasingly emphasised in literature. Previous research separates the terms food loss and food waste (e.g. Parfitt et al., 2010). Food loss is defined as "*...a decrease in mass (dry matter) or nutritional value (quality) of food that was originally intended for human consumption*" (Food and Agriculture Organization, 2013, p. 8). On the other hand, food waste refers to "*...food appropriate for human consumption being discarded, whether or not after it is kept beyond its expiry date or left to spoil*" (Food and Agriculture Organization, 2013, p. 9). To avoid confusion, when referring to food waste and food loss in this thesis, the umbrella term food wastage will be used.

The amount of food being wasted has shown to be rather hard to quantify (Parfitt et al., 2010); nonetheless, the food wastage in the European Union (EU) 2012 was estimated to be approximately 88 million tonnes (Stenmarck et al., 2016). The Swedish Environmental Protection Agency estimates that 1.2 million tonnes of food wastage were generated in Sweden the same year (Naturvårdsverket, 2014), which can be seen in Figure 1. While it is important to mention that part of the wastage produced is unavoidable, unnecessary food wastage occurs at different levels of the supply chain, both due to supply chain inefficiencies and lack of knowledge among consumers (Verghese et al., 2015). Hence, improvements are required from various actors.

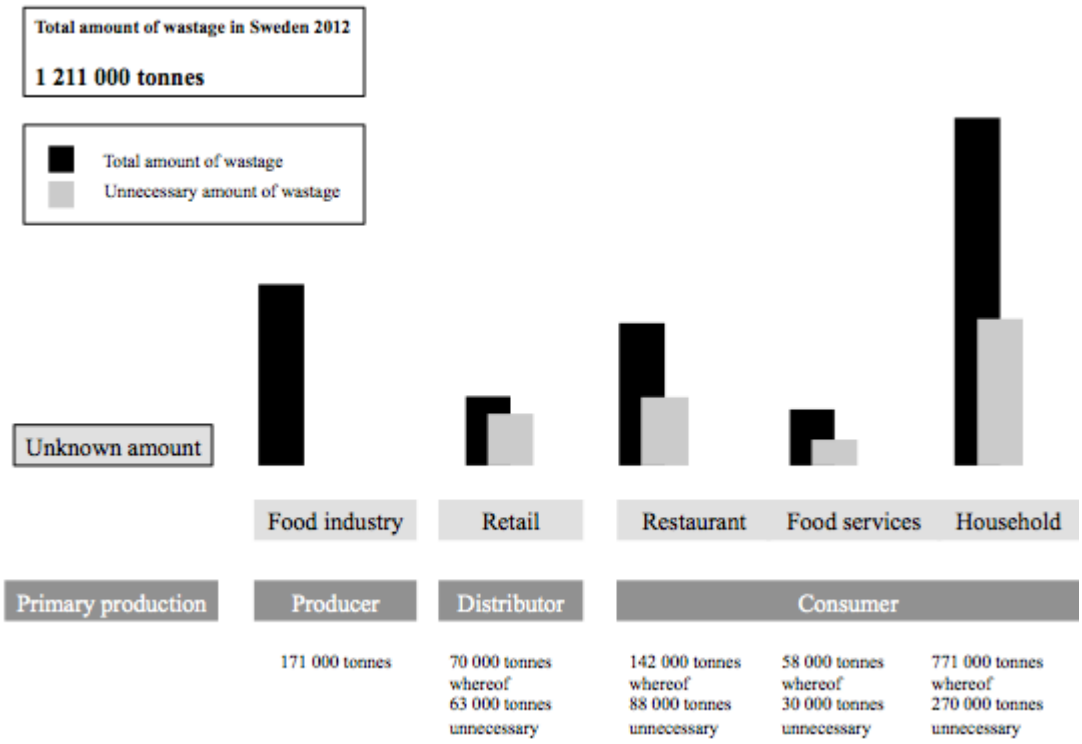

Figure 1. Food wastage in Sweden 2012 (Naturvårdsverket, 2014)

When examining Figure 1, it is evident that the food industry is suffering from unsustainable and inefficient supply chains, as similarly mentioned by Verghese et al. (2015) and Parfitt et al. (2010). The reasons for wastage in food supply chains are addressed by several studies. According to Kummu et al. (2012) the wastage of food tends to occur at the last stages of the food chain. The distribution stage is specifically mentioned as a contributor to wastage and the identified sources are, among others, poor stock rotations and poor handling. For stores, price cuts due to short expiration dates and the inability to sell products with low remaining shelf life are partly contributing to these losses (Eriksson & Strid, 2013; Stenmarck, Hanssen, Silvennoinen, Katajajuuri & Werge, 2011). The total wastage generates large economic losses, €143 billion in the EU during 2012 (Stenmarck et al., 2016). According to Kummu et al. (2012), it is the consumer stage that accounts for the majority of the food wastage; yet, the consumer stage of the food supply chain has received limited attention from researchers of food wastage. A study that has addressed the issue was conducted by Parfitt et al. (2010),

which compiled the main behavioural factors contributing to food wastage at consumer level. The researchers revealed that concerns related to best-before date labels and poor food management in homes are significantly contributing to the wastage.

2.2 Food quality and food safety

As a consequence of extended food supply chains and globalisation, issues connected to food quality and food safety are increasing (Roth, Tsay, Pullman & Gray, 2008). Due to disruption of food supply chains, scholars and practitioners have recognised the growing concerns of food quality and safety (Auler, Teixeira & Nardi, 2016). Society's awareness and concerns related to food safety have grown during the recent years due to previous scandals, which have instilled fear among consumers (Auler et al., 2016; Roth et al., 2008). Food supply chains are generally more complex than conventional supply chains (Aung & Chang, 2014) due to vital trade-offs in quality and supply regarding the products, but also due to the products' nature (Roth et al., 2008). Furthermore, the means of consuming food products (i.e. consuming by eating) makes the issue even more imperative. Despite this, priorities in food safety are trimmed down by external pressure to lower cost (Auler et al., 2016) and as supply chains expand, more actors get involved. These occurrences add difficulties in terms of control and communication between actors (Reiner & Trcka, 2004) and increase the risk for food contamination (van der Gaag, Vos, Saatkamp, van Boven, van Beek & Huirne, 2004).

Temperature is generally recognised as one of the most vital factors that affects the microbiological activity in perishables, and consequently the product shelf life (Koutsoumanis & Gougouli, 2015; Aung & Chang, 2014). Hence, monitoring and control of storage temperature throughout the chain is a necessity (Olsson & Skjöldebrand, 2008). Since perishables are also time sensitive, meaning they have a short shelf life, time and temperature combined can be argued to determine the freshness of these particular products (Aung & Chang, 2014). Temperature breakage along the chain can jeopardise the quality of the food product, thus, also consumer safety, as well as lead to wastage of products, which could have been avoided if handled properly.

Within the food supply chain, there are several critical areas and concerns that may implicate risks for the chain as a whole. Olsson and Skjöldebrand (2008) has identified deficiencies in the chilled food chain, specifically concerning the temperature handling, which if not managed properly can result in significant risks for company reputation and consumer health. Throughout the chain there are temperature related issues and critical points for all actors involved. However, it is not the handling by the individual actors that poses the highest threat but during the shift from one actor to another (Olsson & Skjöldebrand, 2008). While there often are temperature controls at each actor (Kreyenschmidt et al., 2010; Raab et al., 2008), the critical point is rather in between actors (e.g. pallet goods standing at loading dock, waiting times at dispatch, during transport from store to household) (Olsson & Skjöldebrand, 2008). Thus, it can be assumed that the risks increase as the supply chains become extended

and involve an increasing number of actors, complicating the tracing and tracking of products throughout the chain.

2.2.1 Food traceability

Traceability in food supply chains has received significant attention in recent years due to scandals involving disruption in food safety (Meuwissen et al., 2003), also resulting in increased stakeholder pressure and eventually stricter legislations for product traceability (Olsen & Borit, 2013). It is regarded as a subsystem of quality management, yet, can additionally be utilised to improve the collection of information and increase control (Moe, 1998). Ensuring food quality and safety along the supply chain have become challenging (Aung & Chang, 2014), especially due to globalisation, consolidation and commoditisation (Roth et al., 2008). As a result of multiple sourcing from longer distances, standardisation and the absence of regulatory bodies to control large actors dominating food markets, food quality and traceability is challenged (Roth et al., 2008).

Logistics management has become an essential part in food traceability to ensure safety through unique identification of products, which facilitate tracking during transportation and information exchange between actors in the chain (Ringsberg, 2014). Today, food supply chains should provide stakeholders with adequate information of relevance concerning the product (Bosona & Gebresenbet, 2013), including properties of the food product, origin, life history, and the backward and forward movement (Olsen & Borit, 2013). Thus, traceability can be used as a system to effectively monitor and potentially improve safety and quality of food products (Kher, Frewer, Jonge, Wentholt, Davies, Luijckx & Cnossen, 2010).

In literature, many different definitions exist concerning food traceability systems, which is evident in research conducted by Bosona and Gebrensenbet (2013), and Olsson and Skjöldebrand (2008). The definition used differs depending on the sector of the food industry (Aung & Chang, 2014), and type of products and supply chains that the traceability systems are applied to, e.g. cold traceability, which is mentioned by Bogataj et al. (2005). As traceability is utilised to fulfil multiple different objectives, Golan, Krissoff, Kuchler, Calvin, Nelson & Price (2004) explain that the broad definition of the concept is a necessity due to the complexity of supply chains and food products.

The most commonly used interpretation of traceability from scientific articles is developed by Moe (Olsen & Borit, 2013). Moe defines traceability as *"...the ability to track a product batch and its history through the whole, or part, of a production chain from harvest through transport, storage, processing, distribution and sales"* (1998, p. 211). In addition to the capability to track products through the chain, Moe further mentions the importance of the ability to trace products *"internally in one of the steps in the chain"* (1998, p. 211). The European Union's General Food Law Regulation specifically define food traceability as *"...the ability to trace and follow a food, feed, food-producing animal or substance intended*

to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution" (EC 178/2002, article 3). While the regulation argues for the ability to trace and track products and ingredients throughout the supply chain, it is noteworthy that neither of the definitions stated above mention the consumer stage when referring to traceability. In this thesis, the concept of traceability will mainly focus on issues related to the tracing of a product in terms of cold chain management throughout the chain, from producer to consumer. It does therefore not consider traceability concerns related to origin or content.

Issues concerning traceability in supply chains have been extensively covered in literature for several decades (Regattieri, Gamberi & Manzini, 2007), yet the food industry has long had simple traceability systems compared to other manufacturing industries, but these have gradually developed to become more advanced systems (Moe, 1998). The scope of research in the field of food traceability varies from internal focus (e.g. Bertolini, Bevilacqua & Massini, 2006; Dömges & Pohl, 1998) to farm to processing (e.g. Calder & Marr, 1998), as well as to a 'farm to fork' focus, also called chain traceability, where traceability is applied in the whole supply chain (e.g. Kelepouris, Pramatari & Doukidis, 2007; Meuwissen et al., 2003). The farm to fork perspective appears to be the most common. However, the emphasis on chain traceability likely became even more prominent following the introduction of a new EU regulation in 2005, demanding traceability between actors and production units (European Commission, 2007). Thus, requiring companies to track products and ingredients one step back and one step forward in the supply chain (European Commission, 2007; Food Standards Agency, 2002). While the farm to fork perspective is commonly referred to, traceability is seldom applied all the way to the consumer (Aung & Chang, 2014), even though the expression might indicate so. Recently, researchers focusing on supply chain management have emphasised the importance of managing food traceability throughout the chain due to its importance for food quality and safety (e.g. van Rijswijk & Frewer, 2008; de Jonge, van Trijp, Jan Renes & Frewer, 2007).

The growing significance of information and traceability in supply chains was recognised almost two decades ago (Moe, 1998). Yet, traceability is still predicted to experience significant growth developing into a prerequisite for trade (Aung & Chang, 2014; Kelepouris et al., 2007) and an index for quality, as well as an important competitive advantage for food businesses (Aung & Chang, 2014). Despite the development of the traceability concept in food supply chains, previous research neglects to trace the consumer segment of the chain. Thus, merely focuses on traceability until the point of retail (Aung & Chang, 2014). Additionally, a study by Karlsen et al. (2013) concluded that a general framework of how to implement traceability systems is lacking. The authors argued that the absence of a framework creates difficulties for companies when deciding whether to implement a traceability system or not, and that the benefits and risks of a potential implementation need to be carefully investigated. In order to develop an understanding of traceability systems and

their implementation, theoretical contributions concerning benefits and disadvantages are necessary (Karlsen et al., 2013).

2.2.2 EU directives, regulations and legal requirements

The importance of food quality across the chain and efficient food control systems to protect the safety of consumers has increased as a result of globalisation (Aung & Chang, 2014). With more actors getting involved, guidelines and regulations applicable to all supply chain actors are necessary to ensure food control and protect consumers against unsafe products. Consequently, during the recent decades the demands for food quality and traceability has become stricter partly due to several incidents during the late 1990s within the food industry. As a result, the European Commission (EC) decided to establish general principles and requirements for food quality and safety applicable to the member states (European Commission, 2017), such as the regulation (EC) 178/2002. Since Sweden is a member of the EU, legal requirements and regulations enacted by the EU are directly applicable to Sweden and all other members of the union (Livsmedelsverket, 2017a).

According to the EC (178/2002), food businesses are considered to be the most appropriate actor to safeguard the management of food and guarantee safety for food supplied. Thus, *"food businesses should have the primary legal responsibility for ensuring food safety"* (EC 178/2002, p. 3). Due to food safety requirements from the EC (178/2002), food that does not guarantee safety should not be supplied to the market. When determining the safety of food there are certain requirements which businesses need to take into consideration. For instance, consumer usage conditions and the entire food chain including production, processing and distribution need to be taken into account when determining food safety as well as the information given to consumers through labels on packages (EC 178/2002). To ensure that the food purchased by consumers is safe, it is currently illegal in the EU to sell food products after the printed use-by date. On the other hand, food products labelled with best-before dates are allowed to be sold after expiration given that the quality of the product can be ensured (Livsmedelsverket, 2017b).

In addition to this regulation, the European Parliament's Environmental Committee recently voted in favour for a new directive concerning food wastage, aiming for a 50% decrease for all member states in 2030. In contrast to regulation (EC) 178/2002 this new directive is not legally binding (Eklund, 2017); thus, it remains to be seen what effect this directive will have on the food wastage of the member states. Nonetheless, implementing such directives indicates that the European Parliament is aware of the issue and investigates alternative ways of how to manage food wastage. In France, however, a recent legal requirement has banned retailers from throwing away edible food (Carp, 2016), which could put food wastage on top of the agenda and generate an echoing effect in other EU countries.

2.3 Intelligent packaging innovations

Packaging has traditionally had the functions of containment, protection, convenience and communication (Robertson, 2013). Thus, containing products of varying characteristics, protecting the product against the external environment, providing convenience through ease of use, and communicating with consumers for marketing and safety purposes (Yam, Takhistov & Miltz, 2005). The functionalities vary depending on the product being subjected to packaging, as well as market trends and consumer demands (Kuswandi, Wicaksono, Abdullah, Heng & Ahmad, 2011).

Printing expiration dates on product packages became prevalent in the 1970s as a response to consumer demands for indicators of product freshness (Labuza & Szybist, 1999). While packaging has extensively contributed to the development of food distributions systems, today's society demands increasingly complexed packaging functions (Yam et al., 2005). The traditional printed dates are unable to consider variations in temperature, which can significantly influence the freshness of goods, thus do not accurately represent the remaining shelf life of the product (Verghese et al., 2015). Consequently, new packaging materials and technologies have been developed reflecting the changing demands of society. In 2005, Yam et al. argued that the emergent technology of intelligent packaging (IP) or smart solutions had the possibility to facilitate decision making to increase food quality and safety. The authors define IP as packaging that has "*... the ability to track the product, sense the environment inside or outside the package, and communicate with human*" (Yam et al., 2005, p.2).

Furthermore, Yam et al. (2005) suggest that IP can contribute to the flow of information and materials through carrying and transmitting data in the direction of material movement throughout the entire food supply chain cycle. The optimism for the possibilities of IP solutions was similarly mentioned by Dobrucka and Cierpiszewski (2014), stating that their usage can increase product quality and safety, which in turn can prevent food wastage, as well as improve quality of consumer life. The role of packaging to minimise food wastage across the supply chain was likewise mentioned by Verghese et al. (2015). According to Realini and Marcos (2014), the evolution of packaging technology reflects the challenges of a modern society and will play an important role in the food sector in the future through supporting improved food quality, wastage minimisation, reductions in consumer and retailer complaints, and enhanced supply chain efficiency.

2.3.1 Time-temperature indicators

Since the 1960s, technology has significantly evolved resulting in varying types of quality indicators currently on the market (Sahin et al., 2007), including indicators to measure variations in temperature during a set time period. Time-temperature indicators (TTIs) are used to monitor, control and record temperature along the supply chain for chilled and frozen food products (Taoukis & Labuza, 1989). The indicators provide the possibility to observe

actual food quality status and to record temperature history of perishable goods (Lu, Zheng, Lv & Tang, 2013). Hence, can improve traceability, alert about cold chain breaks and indirectly be used as indicators of shelf life (Realini & Marcos, 2014). However, this postulates that the initial quality of the unique product is known; otherwise, the indicator can only predict quality change in isolation (Heising, Dekker, Bartels & van Boekel, 2014).

The literature regarding TTIs is primarily concerned with food science and microbiology, focusing on the characteristics and applicability of the technology for monitoring the conditions of perishable products (Taoukis & Labouza, 1989). Several types of indicators with different functions have been addressed by research, ranging from devices solely indicating if a change in quality has occurred, to more advanced full history indicators that can simulating shelf life (Dobrucka & Cierpiszewski, 2014), as well as indicators measuring actual microbiological growth (Ellouze & Augustin, 2010). Additionally, academia has explored the possibility of using indicators that combine the chemical function with radio-frequency identification (RFID) to effectively transmit and collect product quality information (Herbon, Levner & Cheng, 2014).

Investigations considering the managerial impacts from operational, supply chain and food safety views when implementing TTIs are limited. Sahin et al. (2007) explored the potential value from the use of the technology and concluded that there are expected benefits with a potential implementation. These are mainly related to company reputation and conformity with regulations, as well as operational benefits generated by the real-time information of product quality and remaining shelf life, such as the possibility to implement the inventory management system of least shelf life remaining first out (LSFO). LSFO can prevent expired products to be stored as inventory and can be used instead of the commonly applied principle of 'first-in-first-out' (FIFO). Yet, the authors argue that the benefits depend on the product category and the level of use (i.e. pallet, case or consumer package level) (Sahin et al., 2007). While the study by Sahin et al. from 2007 mentions potential benefits of an implementation, these are solely based on previous theory and the paper does not consider an implementation to the consumer stage of the chain or from a sustainability point of view.

The technology of TTIs has been tested and proven appropriate as an indicator for product quality and product freshness (Taoukis & Labuza, 1989). Yet, while a large amount of literature (e.g. Lu et al., 2013; Ellouze & Augustin, 2010; Kreyenschmidt et al., 2010; Taoukis & Labuza, 1989) argue that the technology offers great potential for monitoring the conditions of perishable products in the cold chain, Raab et al. (2011) noted that TTIs were not extensively applied in meat supply chains. The low number of implementations could be a result of the lack of knowledge regarding consumers' perception of TTIs (Pennanen, Focas, Kumpusalo-Sanna, Keskitalo-Voukko, Matullat, Ellouze, Pentikäinen, Smolander, Korhonen & Ollila, 2015). A study by Pennanen et al. (2015), which investigated consumer perception towards TTIs in France, Greece, Germany and Finland, found that the consumers had positive perceptions and considered them useful but the benefits associated with the technology

differed between countries. On the other hand, the consumers mistrusted the removability of the TTI labels fearing that companies could tamper with them and disliked the possibility of an increase in price accompanying a potential implementation. Yet, more investigations using concrete cases from the food industry are requested to identify actual benefits and possibilities (Sahin et al., 2007).

2.4 Summary of key arguments

Food supply chains appear be more complex and challenging to manage compared to other more generic supply chains due to the perishable nature of the products. The issue becomes even more complex when handling chilled food products as they require a certain storage temperature throughout the chain. Previous scandals within the food industry has brought attention to the deficiencies present in the food supply chain and highlighted the critical points within the food chain. Literature especially pinpoints that the sensitive character of chilled goods generates increased risks, specifically related to temperature control, which are essential to manage properly. Otherwise, it will jeopardise food quality and safety endangering company reputation and consumer health. Thus, it is clear that researchers argue that food control and quality management are imperative for food supply chain performance.

Previous theory has claimed that the successful management of quality throughout the chain is harmed by several factors. First, many supply chains are getting extended with longer distance and more actors involved, while others are very local. Thus, creating difficulties to establish a comprehensive understanding, as well as contributing to the absence of a holistic view of the supply chain. Consumers have often been excluded when scrutinising supply chains despite having been identified as a weak point in the chain and holding an imperative role for supply chain success. Reserachers therefore concludes that the supply chain view needs to be extended to include consumers in order to ensure food quality and safety throughout the chain.

Second, inadequate control along the food chain contributes to poor food quality and produce environmental, economical and societal sustainability concerns as food wastage and economic losses increase, while consumer health is put at risk. Since consumers are often not included in the supply chain view as indicated by Aung and Chang (2014), a large contributor to food wastage is ignored. Consequently, by not paying attention to the poor food handling by households, the ignorance is contributing to environmental issues. Hence, literature argues that efficient systems for tracing and tracking food quality will likely become even more essential in the future as the sustainability debate becomes more intense.

In addition, a general framework for how to implement traceability systems is lacking according to theory, which creates difficulties for firms when deciding whether to implement a traceability system or not. TTIs are mentioned to potentially be a sufficient traceability system as they can monitor and alert about temperature fluctuations and indirectly be used as

indicators of shelf life. In order to provide firms with guidance of a potential implementation, benefits and risks need to be carefully investigated as well as to what extent a system should be implemented.

To summarise, the literature reviewed argues that the food industry is suffering from inefficient supply chains, and lack of knowledge and sufficient tools to manage quality and sustainability issues. It is claimed that an extension of the supply chain view is necessary to create a holistic perspective and to promote control and high quality of food products. An implementation of TTIs as a traceability system for monitoring and recording the condition of food products can potentially improve temperature management within the chain, as well as improve the handling of food products at consumer households. However, currently, research shows that knowledge regarding implementation and expected outcome, particularly all the way to the consumer stage, is inadequate.

3. Methodology

This section describes and justifies the methodologies employed in this research. Initially, the outline of the research is presented, followed by the rationale for the chosen research unit and a detailed description of the sampling process. Furthermore, the methods for data collection and data analysis are outlined. Finally, the section discusses how the qualitative assessments was performed.

3.1 Research philosophy & research approach

This thesis is based upon a relativistic philosophy since the study derives from a subjective nature and assumes that the frame of reference of the observer forms the basis for facts. Thus, numerous truths exist depending on the viewpoint of the researchers (Easterby-Smith, Thorpe & Jackson, 2015). Consequently, meaning is constructed from the interaction between the subjects and the world (Gray, 2013); hence, a constructionist epistemology is applied. To realise the objectives of the thesis, the researchers considered it necessary to observe and experience the food supply chain in its natural context, hence, an interpretivist approach was used. Interpretivism is in line with the fundamentals of constructionism and an important part of qualitative studies where the goal is to grasp an understanding of theory (Eriksson & Kovalinen, 2015). In order to achieve a deeper understanding of implementation of TTIs and its associated benefits and risks, the researchers have interpreted meanings and actions of supply chain actors. According to the interpretivist approach, these interpretations are subjective to the researchers' own frame of reference (Eriksson & Kovalinen, 2015; Williams, 2000), conforming with the relativistic philosophy.

Researchers often apply different kinds of approaches depending on their research (Bryman & Bell, 2015). This thesis is based upon existing theory, which is often related to a deductive approach (Eriksson & Kovalinen, 2015; Bryman & Bell, 2015; Farquhar, 2012). Consequently, the initial literature was used to formulate the purpose and research question of the thesis. Even though previous research within the focus area was reviewed to gain an understanding of current knowledge and estimate its extent, the researchers of this thesis formed a new theoretical framework by compiling relevant topics to structure the research. Additionally, the empirical findings were analysed without predetermined hypotheses or opinions. This way of conducting research is instead in compliance with an inductive approach (Bryman & Bell, 2015), which is why this thesis holds a combination of both deductive and inductive methods, where the inductive approach is being slightly more prominent. Finally, the theory gathered was contrasted against the empirical observations made and compounded in the research analysis.

3.2 Research design

As the aim of this thesis is to contribute with new insights to existing theory, the design of this research is exploratory in nature. The research to date is mainly concentrated on food supply chain management up to point of retail and the technical aspects of TTIs. To fulfil the purpose, a qualitative research design was deemed appropriate as it allows in-depth investigation of the phenomena (Eriksson & Kovalinen, 2015). Additionally, the research questions identifying expected benefits and risks may generate intangible results that are difficult to measure due to the variables being investigated, hence using a quantitative design was unsuitable.

To investigate and scrutinise the research questions formulated for this thesis, the researchers chose a case study design. This enabled for the researchers to get access to both primary data such as interviews and a focus group as well as secondary data in the form of documents and internal reports. Due to the choice of conducting a case study, the researchers could look into the depth of the unit of analysis with reference to the set timeframe of the thesis, conforming to the advantages of case study research (Eriksson & Kovalinen, 2015; Farquhar, 2012).

3.2.1 Research unit

The rationale behind performing a thesis with Coop was formed during the first year of the master program when a Swedish online grocery retailer guest lectured at the school. The presentation and description of the challenges but also possibilities within the industry in general initiated the idea to investigate logistical challenges at Swedish grocery retailers. Shortly thereafter, the researchers contacted the team leader for train transportation at Coop. This led to a forthcoming meeting where a discussion was initiated regarding suggested topics for the thesis. Following, the researchers conducted a brief literature review regarding the topics discussed and Coop internally investigated areas with development opportunities. Later on, after mutual agreements a topic was decided upon, which was feasible for the researchers to perform and of value to the company. As Coop is Sweden's second largest grocery retailer (Dagligvarukartan, 2017) and is one of two retailers that has a presence in all regions of Sweden, it was deemed interesting to have a collaboration with them and receive valuable insights and expertise.

Specifically, this thesis is investigating the chilled food supply chain of Coop, focusing on raw meat products under Coop's own labels. The chilled supply chain was selected due to the high sensitivity of chilled food products in relation to ambient and frozen products; thus, higher risks are involved when handled (Olsson & Skjöldebrand, 2008). Furthermore, there is an extensive debate concerning sustainability and the environmental impact of the growing consumption of meat products (e.g. Jordbruksverket, 2013; Belz & Peattie, 2012; Fiala, 2008), which raises curiosity for inquiring potential solutions to minimise wastage and environmental effects. Meat was likewise regarded to be a suitable unit of analysis due to the

relatively high price of these products compared to alternative chilled food items, such as milk. Hence, making it more feasible from an economic perspective to prevent loss and potentially add an extra cost for a traceability and sustainability solution. In Section 4, extended information about Coop, their meat supply chain and the case itself are provided.

3.2.2 Choice of interviewees

In order to find interviewees providing valuable information to the research, the process of selecting interviewees was based on a snowball sampling method. As the research requires the knowledge of individuals well-acquainted in the topic and the supply chain investigated, a snowball sampling method was deemed appropriate, as further suggested by Biernacki and Waldorf (1981). Snowball sampling is initiated by contacting a minor group of people who fit the criteria for inclusion in the sample and that could further assist with establishing contact with other participants who have experience and knowledge relevant to the research (Bryman & Bell, 2015). The interviewees were selected based upon their role in their company, knowledge of TTIs and/or experience of food supply chains, and the assumption that they could contribute with valuable insights to the study. Initially, the Head of Quality at Coop was contacted due to the importance of food quality inherent to the topic of the thesis. Further on, potential interviewees were suggested by the Head of Quality. Along the interview process, appropriate candidates for further interviews were recommended by the interviewees. All potential interviewees were sent an email with a short description of the project followed by a request of participation in an interview (See Appendix A).

The 15 interviewees selected represented individuals throughout the entire food chain at Coop, more specifically their meat supply chain, including an external producer of meat products, as well as representatives from Coop's central departments of quality, purchasing, supply chain, and marketing. Additionally, two suppliers of temperature indicators were interviewed representing different technical functionalities: TTI A indicates whether a temperature breakage has occurred by destroying the EAN barcode to prevent sales of products unfit for consumption. TTI B integrates the time and temperature aspects to simulate the remaining shelf life of the product. These indicators can be viewed in Appendix F. Furthermore, a complete specification of the interviews performed can be seen in Appendix B.

The focus group participants were selected based on Coop's standard criteria for focus groups. The main criteria for inclusion are that the individuals are regular customers of Coop purchasing groceries at a Coop-store at least four times a month, and that they contribute to dispersion in the group in terms of demographics. After adjusting the sample based on these requirements, six individuals were chosen based on gender, age, level of education, household situation and occupation. The aim was to form a mixed group of individuals in order to take part of different opinions of the varied customer group of a food retailer. A specification of the focus group participants can be seen in chapter 5.

3.2.3 Data collection

Within qualitative research, interviews have been a prominent tool for researchers to use when conducting data (Bryman, 2007). Due to its flexibility compared to quantitative data collection methods, interviews are deemed as a sufficient method when gathering data of qualitative character (Bryman, 2007). This thesis is based on a case study approach and seeks to investigate a phenomenon in-depth within the particular context of chilled meat supply chain, which can provide relevant insights to theory and the industry without attempting to make complete generalisations. Hence, as it allows for a comprehensive analysis of a specific phenomenon (Bryman & Bell, 2015), the semi-structured interview approach was considered appropriate for this thesis.

Being one of the most commonly used approaches, semi-structured interviews hold the ability to provide interviewees with open-ended questions and do not hinder the interview itself from moving freely in a desired direction, while still holding some structure (Bryman & Bell, 2015; Easterby-Smith et al., 2015, Turner, 2010). In accordance to the constructionist epistemology, the reality of the interviewees is constructed through their interaction with the world; thus, the views expressed are influenced by their daily life. It is therefore important to keep in mind that when performing in-depth interviews, they are prone to bias as interviewees might be loyal to the company and do not want to harm the brand image (Boyce & Neale, 2006), as well as are influenced by personal opinions. Furthermore, Boyce and Neale (2006) argue that generalisations are not possible when performing in-depth interviews due to the small sample size and use of non-random sampling. These issues were all taken into consideration when analysing the data.

In addition to semi-structured interviews, an interview with a focus group consisting of consumers was performed in this thesis, in order to understand how this group of individuals react to an issue through in-depth discussions (Bryman & Bell, 2015; Easterby-Smith et al., 2015; Collis & Hussey, 2013). Focus groups are an appropriate tool for understanding the point of view of the participants through observing the interaction between them. As group interaction often brings forward a discussion and argumentation between individuals, the views of the participants may be challenged and the results become more trustworthy (Bryman & Bell, 2015). Furthermore, when using a focus group, a combination of interview and observation is being used, which often generates new interesting results (Collis & Hussey, 2013). However, performing focus group-interviews can be challenging as the researchers have less control over the direction of the discussion and group dynamics often affect the outcome of the interview (Bryman & Bell, 2015). Thus, it is important to have some structure, while still allowing the discussion to have its natural course, as well as closely consider the composition of the focus group and attempt to elicit engagement from all participants.

Secondary data collection is often used as a complement to primary data within research (Easterby-Smith et al., 2015). This thesis was initiated by performing an extensive literature review based on a selection of secondary data sources to identify the existing field of theory and to what extent this research has been scrutinised. The literature review was carried out by screening the title, abstract and conclusion of papers using the following keywords mentioned in the context of food supply chains: 'cold chain', 'time-temperature indicator', 'meat supply chain', 'intelligent packaging', 'traceability', 'sustainability', 'wastage'. The literature search was carried out by using peer-reviewed articles from databases including Science Direct, Emerald Insights and Wiley, as well as public reports from independent organisations. If a keyword was included and the article matched the scope and objective of this thesis, as well as exhibited a clear connection to food supply chains, the article was included in the review.

3.2.4 Interviews and focus group

In total, 15 individuals were interviewed, which was deemed a sufficient sample in order to be able to provide answers to the research questions, while yet feasible within the set time frame. At the end of the interview period, it became evident that the interviewees started to provide similar answers, which could indicate that the sample was adequate (Boyce & Neale, 2006); hence, increasing the sample would not necessarily have provided a different result. 9 interviews were performed face-to-face while 2 interviews were held via Skype and 4 over the telephone. During the face-to-face interviews and Skype interviews the researchers were able to observe the interviewees when answering questions. In contrast, this was not the case when performing interviews via telephone. Since body language and other social cues are not possible to observe when performing telephone interviews, the results may have left out additional interesting findings compared to an interview that allows for visual interaction (Bryman & Bell, 2015).

When performing the interviews, interview guides were used in order to enhance comparability and ensure high quality of the interviews. As previously mentioned, the interviews were semi-structured with open-ended questions which were informed by the literature review and information regarding each company in question. As suggested by Easterby-Smith et al. (2015), the questions were divided into three sections: opening questions, main questions focusing on a number of key questions, and closing questions. Finally, the interviewees were asked whether they had further information to add, if they were available for potential follow-up contact, and if they preferred to be anonymous, as well as whether they could recommend additional individuals matching the criteria for interviewees. The interview questions were similar for all the interviewees within Coop and suppliers within the meat supply chain (See Appendix C); however, minor adaptations were made in order to make sure that the questions fit with the interviewees' position in the company and the specific part of the chain being investigated. For the interviews with the suppliers of indicators, a specific interview guide was developed due to the technical nature

of their products (See Appendix D). Prior to the interviews, all questions were pilot tested on external people with no relation to the thesis in order to avoid misunderstandings or unclarity.

Based upon recommendations from Bryman and Bell (2015), the focus group consisted of 6 participants. For the focus group-interview, a topic guide was developed stating the main areas of interest as this interview was more loosely structured than the individual interviews to enable all participants to express their views and experiences (See Appendix E). The topic guide was designed to allow for unforeseen directions in the discussion; yet, covering the relevant areas (Easterby-Smith et al., 2015). Similar to the interviews, the questions were pilot tested before performing the focus group.

3.3. Analytical process

To analyse the data gathered from the interviews and focus group, the authors recorded, transcribed and coded the data. As qualitative researchers are interested in both what the interviewee says and how the interviewee says it, recording and transcribing are usually made to not overlook important details (Bryman & Bell, 2015). To be able to interpret and discuss the data after the interviews were held, each interview was transcribed and coded separately to ensure that the understanding of the information was consistent between the authors of this thesis. Since the interviews were held in Swedish, the transcriptions were made in Swedish and the relevant findings were further on translated into English. Consequently, the researchers of this thesis are aware of the possibility that meaning may get lost in translation. To minimise this risk, the interviewees were asked to approve the translations made of the relevant findings prior to the publication of this thesis. Additionally, the researchers of this thesis are aware of that the information gathered might be prone to bias due to the sampling and data collection method. This was carefully taken into consideration by the researchers through applying a critical approach when gathering and analysing the information.

In order to analyse and structure the large amounts of data gathered, coding was used to enhance the credibility of the analysis. The coding of the data was performed in Microsoft Excel to structure the findings from the transcriptions. Coding involves the data being divided into groups and given different labels forming core themes relevant for the topic, a method known as grounded analysis (Easterby-Smith et al., 2015), and is based on the search for recurrences of themes within the data (Bryman & Bell, 2015; Easterby-Smith et al., 2015). In compliance with grounded analysis, the aim of this thesis is to build new knowledge complementing existing theory instead of testing existing theories. Thus, the meaning of the data should be the basis for the themes constructed rather than structuring data around pre-developed themes (Easterby-Smith et al., 2015). The procedure of the coding process went on as following: if the interviewee, for instance, mentioned lack of accuracy in routines or old fashioned system then these codes, together with similar information provided by other interviewees, formed the category ‘Risks’. Then, further on in the coding process, all categories were grouped together into more comprehensive themes, such as

‘Implementation’. The themes were reviewed throughout the process to ensure their relevance and consistency. If one theme lacked a clear distinction from another, these were merged together, while themes without a clear connection to the topic were excluded. Finally, 98 codes were identified and divided into a total of 11 categories which formed the 5 themes of ‘Quality’, ‘Efficiency’, ‘Implementation’, ‘Communication’ and ‘Future’ (See Appendix G).

3.4 Qualitative assessment

To address and establish the quality of research, there are several approaches that can be considered. The dedicated approaches for measuring validity and reliability for quantitative studies have been criticised in terms of their applicability to qualitative research. Instead, trustworthiness has been presented as an alternative method to adapt the concepts of validity and reliability for studies where measurements are not a major preoccupation (Bryman & Bell, 2015). As this research is of qualitative character seeking to understand a phenomenon without quantifying it, the concept of trustworthiness is considered appropriate. Additionally, the concept conforms with the relativistic approach, which is in contrast to the view of a single absolute truth associated with the conventional approach of validity and reliability (Guba & Lincoln, 1994).

Trustworthiness is based on four elements; credibility, transferability, dependability and confirmability (Bryman & Bell, 2015; Farquhar, 2012). First of all, as there are numerous existing truths of reality, credibility is a prerequisite for the trustworthiness of research (Bryman & Bell, 2015) and for case studies in particular (Farquhar, 2012). The purpose of this study is to conduct an in-depth investigation. Consequently, interviews and a focus group with experienced and knowledgeable interviewees within the field of research representing different parts of the supply chain enabled for a holistic view of the phenomenon being scrutinised. Furthermore, applying semi-structured interview guides allowed for open discussions providing the possibility to take part of the individual opinions of the interviewees.

Due to the exclusivity of its own context, case studies are limited in terms of transferability as this refers to the generalisability of the study (Tsang, 2014; Farquhar, 2012). Despite the possibly scarce transferability of case studies, Tsang (2014) argues that this type of research can be generalisable since the studied phenomenon is likely affected by the context. Yet, the aim of this thesis is not to make generalisations; it is rather to generate insights regarding the issue within the studied situation that can serve as a basis for future research within the fields of TTIs and traceability systems, as well as sustainability systems. The thesis can also contribute with relevant insights for the industry since the main actors on the Swedish market have relatively similar characteristics, although the findings not being strictly applicable to other retailers.

Since case studies may change turns during its procedure (Farquhar, 2012), it is essential to carefully provide information concerning the course of action (Bryman & Bell, 2015). To ensure high dependability and trustworthiness of this study, a supervisor, peers and external reviewers have examined the research process to confirm comprehension of the execution. Additionally, while the philosophy of this research assumes the inability of objectively conducting investigations, the researchers of this thesis have not intended to guide the thesis in any desired direction and acted in good faith.

3.5 Limitations

Since a single case study has been performed in collaboration with a specific company within the Swedish grocery retail industry there are limitations inherent in the method, which need to be taken into consideration. As previously mentioned, applying a single case study inhibits the possibility to make complete generalisations of results due to the company specific focus. Moreover, the relativistic approach of the study entails that the interviewees and researchers have likely influenced the outcome. Subsequently, the result may have been different in another context. However, the application of a single case study and was a conscious decision to arrive at a contextual understanding of the investigated phenomenon.

The snowball sampling method might impact the results since the referrals given by the interviewees can generate bias as all interviewees were not able to recommend potential candidates. The authors of this thesis argue that the sampling method was appropriate due to the limited access to knowledgeable individuals. Additionally, the group of interviewees is argued to contain individuals from the entire supply chain and from various departments at Coop that might be involved in an implementation. Furthermore, the consumer opinions are based on a focus group interview; hence, this solely provides an indication of the overall consumer response to TTIs. A more extensive investigation of consumer demand prior to an implementation would give a more reliable indication of consumer attitudes. Yet, such an approach would be more time consuming and cannot regardless be taken as a guarantee of actual consumer behaviour.

4. Coop - Case description

In this section, information about the Swedish food industry is presented followed by a description of Coop as the unit of analysis. Furthermore, Coop's chilled food supply chain is described in order to give an overview of how chilled goods flow from producer to retailer. All information about Coop is based upon their annual report from 2015 and their website, as well as personal contact with the company.

4.1 The Swedish food industry structure

In 2014, the industry of food and beverages in Sweden generated sales of 349.1 billion SEK (Chamber Trade Sweden, 2016), whereas sales generated from the Swedish food retail sector accounted for 238.1 billion SEK (Dagligvarukartan, 2016). The Swedish food industry is comprised of many small and medium sized actors; however, the industry is still regarded to be highly concentrated (Eriksson et al., 2016). The market is characterised by numerous producers and retailers, while few wholesalers exists, as visualised in Figure 2. Yet, commonly, the Swedish wholesalers and retailers often operate under the same umbrella organisation (Olsson & Skjöldebrand, 2008). Hence, the concentration is regarded as high since the majority of the market is controlled by four major retail chains. The ICA group, Coop, Axfood and Bergendahls are considered to be the dominant players as these actors combined represent 94.1% of the total market shares (Bränström, 2015). Internationally, the structure of the Swedish food sector is unique with the highest concentration in Europe (Bränström, 2015). The high concentration is further emphasised by one actor, the ICA group, dominating the market holding approximately half of the total market shares (Lindow, 2012). Additionally, the dominance is further increased as each of the four major actors offers products under their own brand labels. Consequently, issues regarding bargaining power have arisen due to the current market structure. Additionally, this has raised concerns regarding environmental issues and food prices as productivity and volumes have increased but not competitiveness (Eriksson et al., 2016).

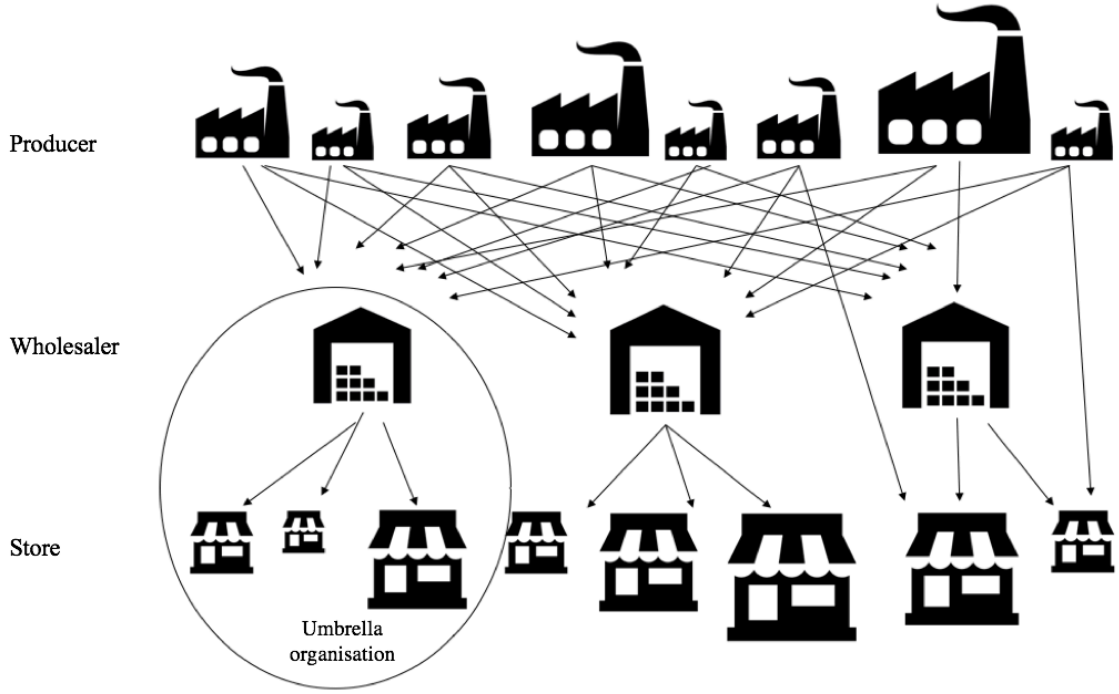

*Figure 2. Swedish food industry structure (Adapted by the authors, based on Olsson & Skjöldebrand, 2008, p.52)**

4.2 Coop

Coop Sweden AB is a Swedish grocery retailer chain, owned by the consumers as the majority shareholder is the cooperative organisation (KF) founded in 1899. KF is a consumer cooperative based on promoting high food quality and affordable prices to create financial benefits for their members while contributing to sustainable development for society and the environment (Coop, 2016). Today, Coop is the second largest grocery retailer chain in Sweden with 655 stores in Sweden ranging from Katterjåkk in the north to Smygehuk in the south (T. Norrström, personal communication, 7 February 2017). In 2014, the market share of the organisation corresponded to 20.5% with a net profit of 34.2 billion SEK (Coop, 2015). Fundamentally, Coop strive to be the good force within the Swedish food industry through emphasising sustainability by focusing on ecology, health, affordable prices, strong private labels and a unique loyalty programme (Coop, 2016). Currently, Coop offers products from external brands as well as from three private labels, Änglamark, Coop, and Coop X-tra. Änglamark is an organic brand aiming to deliver a wide assortment with high quality, the Coop brand offers carefully selected food products with high quality and an affordable price, while Coop X-tra provides a basic assortment with larger volumes to low prices (Coop,

*Icons made by Freepik from www.flaticon.com

2017). The production of these goods is outsourced to reliable producers with whom Coop has established close relationships (T. Norrström, personal communication, 7 February 2017).

4.2.1 Chilled food supply chain

The information provided within this section is based upon personal communication with T. Norrström, 7 February 2017.

Coop is a centralised organisation; thus, the control over the supply chain is exercised from the headquarter in Solna where the supply chain department is responsible for store and warehouse replenishment all over the country. The operation is organised based on the flows from producer to head terminal and consolidation centre, and from terminal through consolidation centre to store. Additionally, the flow of goods within the supply chain is divided into three product categories; dry goods and non-food, perishables and chilled products, and frozen goods. These goods are procured from a total of approximately 2500 suppliers, where domestic suppliers correspond for the major share. Consequently, the items arrive at one of three main terminals depending on the characteristics of the product. For the Coop labelled meat in specific, the products are procured from a Swedish external producer (primarily Scan) and arrive together with the majority of perishables and chilled products at the terminal in Västerås. Here, the products are cross-docked before delivered to store or transported to consolidation centres prior to delivery at store. This is not the case for bread and dairy products which are shipped directly from producer to store. The entire road fleet and seven consolidation centres are externally managed by third party logistics (3PL) providers, while the producers and stores in the southern parts of Sweden are served by a train operated by Coop. The train was put in use in 2009 and its importance has developed significantly to currently account for 30% of the total number of transported goods. Figure 3 illustrates a simplified version of the Coop supply chain.

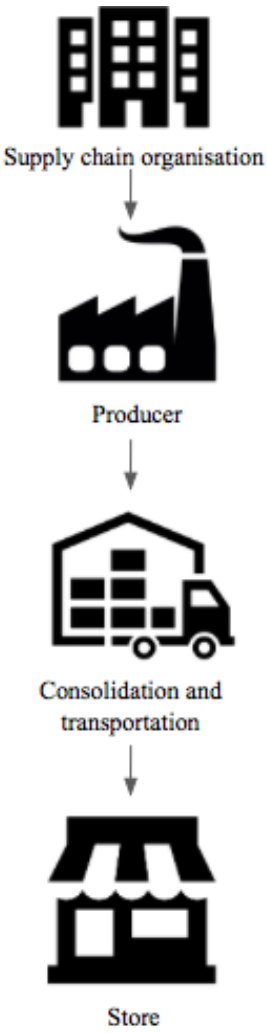

*Figure 3. Part of Coop's supply chain**

* Icons made by Freepik from www.flaticon.com

Quality characteristics for chilled products, including temperature, are regularly controlled from producer to store. Controls are made at terminal, during transportation and at store to ensure that all product categories are held at an individually set temperature range, in accordance to the current legislation. For meat products, the lead time from point of packaging to store is generally 48 hours. Furthermore, the inventory at the stores are managed according to the principle 'first in-first out' (FIFO); however, in order for the products to be received by the store the minimum remaining shelf life should be approximately 70% of the total days to expiration.

As discussed throughout the case description, it is evident that Coop has a complex supply chain network where a large number of intermediaries are present. Although Coop has established a close collaboration with the external actors and consider that they are able to ensure food quality and safety, the question still remains at what level it is possible to secure traceability and safety throughout the supply chain. Additionally, issues concerning sustainability, especially at consumer level, have been raised within the organisation as food wastage is a major obstacle towards a sustainable food industry. Hence, the food industry is in need of future development and innovations to secure the food supply chain and minimise its negative impact on the environment and society. Consequently, Coop is investigating potential solutions, including TTIs, where they as a retailer are able to influence the progress positively and promote efficient and sustainable supply chains, from producer to consumer. Therefore, it is a necessity to investigate the impact of a potential implementation of these solutions in a real case scenario. The following section outlines the findings from the interviews, which investigated the potential benefits and risks of an application of TTIs as well as how these can be efficiently implemented.

5. Empirical findings

The views and opinions gathered from 15 interviews and a focus group are presented in this section. All data has been coded, consolidated and presented in themes occurring from the interviews themselves. The section is structured into themes and subcategories where information from both interviewees and focus group participants is presented. The entire section is finalised with a summary of key findings.

To structure the primary data gathered, all findings were coded and grouped together into categories in relation to their context. Thereafter, common themes were identified for the categories, which represents the headings within this section. The entire coding scheme can be found in Appendix G. In order to map the topic of who is saying what throughout the section, both the interviewees and the focus group participants have been given a letter combined with a number. The interviewees are marked with an '**I**' and the focus group participants are marked with the letter '**F**' followed by an individual number. As seen in Table 1, the interviewees are divided into five groups; headquarter departments (**I**1-**I**6), producer (**I**7), distribution (**I**8-**I**10), store (**I**11-**I**13), and suppliers of indicators (**I**14-**I**15). Appendix B provides further information about the interviewees. The specification of the focus group participants is outlined in Table 2 in this section.

Table 1. Interview list

Interviewees		
Interviewees	**Company**	**Position**
I1	Coop	Head of Quality
I2	Coop	Quality Manager
I3	Coop	Purchase and Category Developer
I4	Coop	Supply Chain Manager
I5	Coop	Sustainability Strategist
I6	Coop	Store Quality Manager (HQ)
I7	Scan	VP Quality and CR
I8	Coop	Quality and Master Planning Manager, fresh goods
I9	Coop	Transport Planning Manager
I10	Postnord	Production Manager
I11	Coop	Regional Store Quality Manager
I12	Coop	Anonymous
I13	Coop	Store Manager
I14	Supplier of TTI A	CEO
I15	Supplier of TTI B	CEO & Country Manager

Table 2. Focus group participants

Focus group participants					
Participant	**Gender**	**Age**	**Level of education**	**Household**	**Occupation**
F1	Female	28	One year master	Cohabitation with children	Parental leave
F2	Male	30	Bachelor	Cohabitation	Full-time
F3	Female	25	Master	Cohabitation	Student
F4	Male	53	Upper Secondary School	Cohabitation with children	Full-time
F5	Female	26	Bachelor	Single household	Full-time
F6	Female	47	Bachelor	Cohabitation with children	Full-time

Readers may find it useful to occasionally return to these tables to see the titles and specifications of the persons referred to in this section. When the title of the interviewee is of importance, it is outlined in the text.

5.1 Quality

Quality is a vital factor within the food industry and high on the agenda at Coop, confirmed by a consensus of the interviewees. **I**1 explained that, for meat products, quality management essentially includes focusing on traceability and temperature along the supply chain to ensure safe and high quality products. **I**4 elaborated on this stating that "*of course temperature is of great significance for the quality of the product…hence, it is incredibly important that it [the product] is handled in a correct way"*. The significance of temperature was likewise mentioned by **I**3 *"It is important with quality and that the cold chain is intact all the way from packaging to the stores, all the way from packaging to the customers actually. It affects the shelf life, discolouration, well everything really"*. **I**6 drew a parallel between the handling of products and food safety, arguing that correct handling and traceability is vital for the safety and health of consumers.

From the consumer perspective, the quality and safety of the food products are critical. **F**6 explained *"I do not think too much about myself and what I eat, instead I think about my three children and that they do not consume anything bad. So, that is what quality means to me, I mean that they get good food"*. The freshness of the products was considered important and the majority of the consumers claimed that the best-before date was a significant determinant when grocery shopping and when consuming food products. This was especially the case for perishables *"I am really anxious regarding perishables and never exceed the best-before date, but with dry food it is not a problem"* (**F**5). Yet, **F**2 stated that *"My first thought regarding best-before dates is that you can use it a few extra days. I do not follow the dates strictly, if it is a few days past the best-before date it is still edible"*.

During the discussion on quality and food safety, **F**4 and **F**5 focused the attention on the handling of products as **F**5 expressed *"I think about the packages and that you can trust the packaging, the date stamps, and handling during transportation. Everything that you do not really know anything about, it is important that you can trust it"*. **F**4 similarly concluded that trusting the handling of products is important. **F**5 elaborated *"you have to trust it, otherwise you would not be able to eat anything. Then you would have to grow everything yourself"*. While the majority of the consumers generally trusted the handling of products, **F**1 mentioned that scandals in the food industry raise concerns and often increase the uncertainty regarding food safety.

5.1.1 Quality processes

To have processes and a standardised way of working with quality parameters in all stages of the chain are essential in the food sector. To ensure quality and food safety along the chain, **I**11 emphasised the industry standards which all actors in the sector are required to conform to and preferably surpass. For Coop, this includes demanding high quality, accurate temperature conditions and proper handling for all internal activities, as well as for all suppliers. Throughout the chain, interviewees involved in quality management, production, distribution, and sales of meat confirmed the strict control including regular temperature tests and spot-checks at facilities and vehicles used. **I**2, **I**6 and **I**8 mentioned that for Coop's internal activities, mainly terminals and stores, there are guidelines and strict demands on internal control of quality and temperature, as well as product handling. **I**2 explained *"they [the terminal] control every vehicle that arrives and make sure that the temperature of the products is correct when entering the terminal"*. At the store level, **I**6 stated *"All stores are required to have some sort of self-monitoring system, meaning that they themselves follow-up on their work according to a quality programme"*. Additionally, **I**6 and **I**12 mentioned that the actual procedures are locally adjusted based on the central policy and legal requirements.

For external suppliers, there are likewise strict quality requirements and control systems. **I**7 explained that the control performed at Scan, the supplier of Coop's meat products, are extensive measuring microbiological growth, sensory aspects of the meat, and the temperature of inbound activities and outbound deliveries. Regarding the transport providers, **I**9 stated *"We have pretty strict quality requirements concerning temperature but also how the products or pallets should be handled, how they should be checked, and how to maintain traceability all the way"*. Elaborating on the topic, **I**8 stated that even though there is an EU regulation requiring traceability in food supply chains, the responsibility of how to establish such control is up to each actor.

To ensure correct handling, **I**1 explained that *"there is a quality system in all parts of the supply chain. And it is a little more complex in the beginning and end, and a little less [quality] parameters in the middle during transportation"*. Several interviewees mentioned that Coop, as well as external audit firms, measure and follow-up on the set quality demands

through regular controls and audits at all internal and external actors in the chain. **I**1 mentioned *"... we do a pure follow-up check using temperature pucks to see the entire cooling process"*. **I**10 and **I**12 also discussed that the distribution staff and store personnel are continuously undergoing training to generate an understanding of why quality is important and how to handle perishable products properly.

5.1.2 Quality risks

In order for a food retailer to sell products, the consumers need to trust that the products have been properly handled, as mentioned by **F**5. Ultimately it is the responsibility of each individual actor to ensure compliance to the legal requirements and the quality demands of Coop, as indicated by **I**2, **I**10 and **I**11. **I**1 explained that the quality risks in the chain are highest during production and at the stores due to the handling of open products, meaning products without packaging. To ensure quality, the industry commonly conduct spot-checks to measure temperature in the product environment, as previously mentioned.

Several interviewees involved in the quality management of meat products argued that the current method is a good indicator for monitoring quality; however, measuring every individual consumer package and receiving information regarding temperature history of the storage conditions would improve the accuracy of the monitoring, according to **I**1, **I**2, **I**8 and **I**14. **I**2 argued "*It is an old-fashioned system, we have been using thermometers for a very long time, and they have a rather high margin for errors, they have a margin of plus/minus 0.5 degrees*". **I**14 added "*It actually requires 14 temperature monitors to be completely certain that the temperature is correct in the whole vehicle during the entire transportation*". Additionally, the issue of history was raised by interviewees who claimed that temperature spot-checks do not reveal what has happened prior to the check conducted at the arrival of goods at terminals or stores. Furthermore, time limitations were of great concern when discussing risks with temperature and quality controls in food supply chains and **I**1 mentioned that the current method of measuring temperature is too slow. Furthermore, **I**1, **I**2 and **I**10 argued that human errors and lack of knowledge are two of the significant risks in a chain and **I**2 stated *"... as soon as a human is involved in a process there is always a risk of making mistakes"*. Yet, according to **I**10 *"When the process is followed correctly it is watertight"*.

5.2 Efficiency

5.2.1 Time pressure

In general, when discussing processes at different levels within the organisation the majority of the interviewees related their answers to time pressure. The interviewees claimed that time always matters in one way or another within Coop and that it constantly needs to be carried in mind. **I**4 expressed a primary focus on efficiency "*We want to be able to deliver the freshest*

possible products to store. And we want to deliver these products as fast as possible to store". **I**8 explained "*Coop's intention is to give at least 50% or more of the total lifetime on fresh products. In the vast majority of cases, we are able to provide our stores and consumers with almost two thirds of the total durability... This voluntary intention in turn creates a very short time window for us to handle these products. Meat for instance is one of these products*". **I**9 and **I**10 also elaborated on short lead times within the food supply chain and **I**10 explained that the fresh meat products barely stand still at any point in the chain.

I11 commented on time restrictions by stating "*Time constraints are one of the greatest challenges we have in general in stores. To decrease cost by decreasing time*". Another interviewee (**I**12) elaborated on the topic and discussed that daily processes in stores, there among quality controls, often are time consuming. **I**12 expressed concerns for smaller stores where any loss of personnel, due to illness or other events, may generate situation that forces the staff to prioritise between serving the customers and conducting quality controls on incoming goods. **I**9 addressed the time constraints by mentioning that random testing and spot-checks are manageable within the given time frame the stores currently have.

5.2.2 Cost

When interviewing employees at Coop it became evident that cost holds a primary focus and is a common denominator through all stages. **I**11 pinpointed the overall debate by saying "*It is always about money within this sector*". At the production and distribution stages in the chain, cost was primarily related to investments in equipment; whereas further down at store level cost was argued to be closely related to time.

For consumers, price was presented as a central factor when grocery shopping and cost was a recurring theme throughout the focus group interview mentioned by all participants. The price sensitivity and emphasis on cost were present during the discussions on quality and food wastage. The majority of the consumers suggested that the price of the product was highly correlated with the quality, handling and treatment of the animal. Moreover, the consumers agreed on that the price of the products affects the amount of wastage produced as more expensive products are rarely disposed of; as **F**6 put it *"then I throw away money since I have payed money for it"*. However, the majority of the consumers had a negative perception concerning price reductions on food products with short remaining shelf life. **F**6 explained *"I would not purchase it [products with short remaining shelf life] in store, I want the freshest if I am going to pay for it"*. Yet, generally the focus group participants appeared less price sensitive regarding expensive products and when purchasing groceries online.

5.2.3 Food wastage

When initiating a discussion regarding food wastage, the majority of interviewees agreed upon that wastage occur at all parts of the chain; yet, the largest contributors to this issue

were mainly stores and consumers. **I**6 argued *"Food wastage is a general problem in the entire chain and therefore I think we have to work with this at every stage. But of course, you have to prioritise and investigate where the problem is most severe, at what part of the chain."*. From producer to store, the interviewees argued that food wastage generates unnecessary expenditures and was caused by a variety of reasons including overproduction at suppliers, and inefficient processes in the chain. **I**7 explained that overproduction can occur for orders differing from the forecast, which are often placed close to delivery to not risk stock-outs. Likewise, **I**12 argued that part of the wastage generated by stores is due to personnel overstocking to encourage purchases and avoid having empty shelves. Regarding ordering processes, **I**13 argued that deliveries on automatic ordering might sometimes cause problems such as ordering larger quantities than necessary; hence*, "it is important to have control, and if we do not have control, especially when it comes to meat products since they are expensive, this might cause a great deal of food wastage*". Yet, **I**13 cares to highlight that this is not a common problem they have in store.

The consumer stage was especially pointed out as the main contributor to food wastage and lack of knowledge was the overall response from the interviewees when discussing consumer food wastage. **I**1 argued that *"the industry itself is very efficient in its processes. But when looking at households, that is where the largest amount of energy is consumed and the largest amount of food wastage occur"*. **I**8 agreed and another interviewee (**I**2) added "*I argue that consumers are the largest quality risk because they do not have the knowledge of how to handle food properly*". **I**1 and **I**13 implied that society's fixation with best-before dates is part of the problem and **I**8 argued *"expiration dates are too unclear"*.

The concern regarding the accuracy of best-before dates was similarly mentioned by the consumers themselves, arguing that many people are strictly basing the freshness of a product on the best-before date. Furthermore, the focus group discussion revealed that most of the consumers seldom reflect on their handling of food product in the stores as well as on the handling of food products at home. Hence, the consumers rarely reflected on the temperature requirements of meat products while they are carried around in the store, sometimes for over an hour. Similarly, no reflections regarding the handling of food beyond the point of restocking the refrigerator after purchase were mentioned. Nonetheless, the consumers displayed a concern regarding food wastage and **F**3 stated *"I anguish when I have to throw away food that has gone bad"*. When discussing food wastage, consumers buying groceries on a weekly basis claimed to buy larger volumes and put in the freezer, and thereby avoid unnecessary food wastage. Instead, daily grocery shoppers expressed that they buy only what is necessary for the day and consequently do not end up with excessive amounts of food in their fridge. While all the participants admitted that they threw away food, the food wasted was primarily cooked food thrown away due to poor planning or food that had been forgotten. Additionally, the participants all claimed that expensive products such as meat were rarely wasted.

While the issue of food wastage was generally portrayed as a negative phenomenon in the food industry, **I**1 pointed out that the society and the industry desires food wastage. The interviewee explained:

"It would mean that the farmers would decrease their production with 30%, so it would significantly affect that sector. And the stores would sell approximately 10% less food. No one will be happy about that. And the customers at home, well they want food wastage. They like to have lettuce in the refrigerator to be able to serve something nice in case they got visitors. Risking that the lettuce goes bad and have to be thrown away is worth it. So, the system has overproduction because there is a desire for it. There is no interest in any group to reduce the food wastage"

5.3 Implementation of TTIs

When presented with the idea of a solution that could indicate a break in the cold chain, all the interviewees involved in the Coop supply chain were initially positive to the technology. Overall, these interviewees agreed upon most of the topics discussed; while there were discrepancies regarding some issues. The majority of the interviewees saw great potential in the technology and how this could help to increase traceability and control within food supply chains. However, depending on where the interviewees are operating in the supply chain and to what extent they have previous knowledge of the technology, the interviewees saw a varying amount of advantages with implementing the technology. Generally, interviewees operating early in the supply chain were more sceptical and saw less potential with TTIs mostly due to not handling individual consumer packages in their processes. Hence, the majority of the interviewees with positive attitudes were either operating at the end of the supply chain or had previous positive experience connected to TTIs.

Overall, the consumers in the focus group were likewise positive to the technology as a concept. Still, they raised concerns regarding its implementation and how it would affect the retailer and the consumers. Additionally, the focus group participants presented differing attitudes towards the attractiveness of TTIs from a consumer perspective.

5.3.1 Benefits

Increased traceability, improved food safety and growing consumer awareness were mentioned as the primary benefits associated with an implementation of TTIs by the majority of the interviewees. **I**2 more specifically saw the potential for more efficient quality controls "*It is a quick control at terminal, it is a quick control at store and if this is correctly installed, we can guarantee that nothing has happened [to the products], and then it is a good quick control*". The same interviewee added that the indicators could help stores sell more products as the store manager can display the products with shortest remaining shelf life instead of the shortest best-before date. Additionally, some interviewees expressed how the technology

could be beneficial in terms of creating more efficient processes that could improve the quality of products and minimise human errors. "*I believe a great advantage would be increased accuracy when performing temperature controls at store*", mentioned **I**11. **I**3 argued in line with this and stated "*I think there is a great challenge to not put too many stock pallets in store when doing replenishment*" and emphasised that an indicator probably could help improve the handling of products in store. **I**9 mentioned that an implementation would be advantageous since it would provide a better overview of the entire supply chain even though keeping existing processes.

Most interviewees argued that an implementation would be most beneficial for the consumers and the environment. **I**15 argued "*It [a TTI] is like having an employee [controlling temperature] on each of the fresh food packages*". The TTI supplier (**I**15) continued by highlighting that dynamic best-before dates individually adjusted for each product can decrease food wastage at several stages in the chain by constantly monitoring the temperature and quality for each individual product. Likewise, **I**12 mentioned that indications of cold chain breakage could improve the handling of perishable food products for both supply chain actors and consumers. Several interviewees also argued that an implementation would conform to the consumers' growing awareness regarding sustainability related issues. One of these interviewees (**I**2) pinpointed how it might generate a so called 'first mover advantage' with implementing TTIs in the near future ahead of competition. Another interviewee (**I**1) mentioned goodwill and financial benefits "*Hopefully, an implementation would cause a goodwill effect in terms of appreciation from our consumers. And then [the implementation] could lead to them buying their groceries in our stores, which we, of course, would appreciate*". Overall, the majority of the interviewees at Coop claimed that in the long run, a solution will probably become beneficial due to economies of scale and processes being built up within the organisation, as well as generating positive effects on consumer trust.

In general, the consumers regarded TTIs as beneficial for several reasons, including food quality and safety. For instance, it was mentioned that it would put pressure on all the actors handling the product, from production to stores, as argued by **F**1*"It puts pressure on the suppliers as the indicators cannot be too abused since those products won't be selected [by consumers]. Then they might have to throw away products that otherwise would have been sellable".* Additionally, **F**6 emphasised the benefits from dynamic best-before dates and argued that the consumers themselves can see the actual remaining shelf life of a product and that the knowledge of how to handle products would increase. **F**1 mentioned *"I would not dare to eat if it [the indicator] had indicated that the days had expired, in that case I would have thrown it away. But with best-before dates I feel that you need to also rely on your senses. That one [the indicator] is more precise; the best-before date is still an estimate"*. All the consumers were positive to using indicators at home and **F**2 stated *"I would be affected and would want to maintain the temperature or, if I had purchased it [the indicator] I would think more about putting food into the fridge quicker and be even better at it so that it would not be triggered"*. When discussing the perception towards the initiating retailer, all the

consumers stated that an implementation would positively affect their perception of the brand and increase their trust of the retailer. **F**1 further argued that the implementation might also be a source of competitive advantage for retailers if consumers start to question the safety of other retailers' supply chains without indicators.

5.3.2 Risks

For the supply chain actors, regardless position at Coop, or if being an external supplier of Coop, there was a general concern among the interviewees regarding the cost and time aspects associated with an implementation of TTIs. The majority of the interviewees at Coop pointed out that from a short-term perspective, an implementation would most likely be both expensive and resource intensive. **I**2, however, pointed out "*initially, all these novelties are expensive, it is the same with all kinds of technologies, it becomes cheaper over time*". From a time perspective, the technology was argued by **I**6, **I**11 and **I**12 to probably require extensive resources, especially for stores in terms of initiating new processes and training store personnel. **I**12 additionally proposed a risk regarding relying too much on the technology as it diminishes the need for store personnel to have sufficient knowledge themselves. At the same time, from a producer perspective, one interviewee elaborated on cost and time aspects for an implementation as "*Either it will take longer time or we have to hire more people*" (**I**7).

Apart from the factors of cost and time, the interviewees had various concerns regarding an implementation of TTIs. **I**1 criticised the technology for being analogue and argued "*To control and follow the cold chain you have to have digital information*". Another interviewee (**I**6) was sceptical towards the entire technique and the risk for incorrect installation causing economic losses by increasing unnecessary food wastage. **I**1 similarly mentioned that the technology may not be appropriate for all meat categories as it can endanger consumer health if implemented using incorrect settings on highly sensitive meat products. The scepticism against the indicators was also reflected upon by **I**11 who considered what would happened if increasing amounts of temperature abuse would be revealed at Swedish retailers. This critique was responded by **I**14 and **I**15 asking how poor products do retailers actually want to sell. **I**3 emphasised that the retailer may not always be responsible for the abuse "*There might be a situation where we have kept our cold chain intact, but the consumer spends a lot of time in store, then it is the consumer who have ruined the cold chain. And then the store still has to pay for that*".

Limited traceability was also argued to be a drawback related to the technology, which in turn was related to TTIs not being used by all actors along the chain. **I**8, who is involved in the distribution of products, explained "*What is important to know is that we do not handle consumer packages… We handle larger packages. So, the difficulty is still that we would never see that indication*". Being at the production stage of the chain, **I**7 likewise stated "*It is not at our stage that a reaction on the indicator would be detected. It is either at the store or*

at the consumer". Furthermore, the suppliers of the indicators (**I**14 and **I**15) themselves confirmed a limitation with the technique by stating that the technology itself cannot determine the initial quality of fresh products, it only reveals if there has been a temperature breakage from the production stage and forward. Moreover, the interviewed consumers raised concerns regarding the removability of the indicators at less trustworthy retailers, which was confirmed by **I**14 and **I**15. However, exchanging them for new labels would be resource consuming since they need to be triggered by a machine at attachment.

When discussing the TTIs during the focus group interview, the consumers were primarily concerned with the potential increase in price that might accompany the implementation of the indicators. **F**1 stated *"for me there is a threshold, just as there is for organic food, I can purchase organic food to some extent but there is limit for when it is worth it in terms of price"*. Moreover, discussions were initiated by **F**6 regarding the possibility that consumers start to question the purpose of the implementation and raise questions regarding why it is necessary to indicate that the cool chains are intact. Additionally, the consumers were divided when addressing the impact an indicator may have on food wastage. **F**3 mentioned *"It may generate more food wastage as people might not want to buy the products the indicator shows a breakage. You will become pickier in the store, and even I might reflect on it [remaining shelf life]"*. In contrast, **F**2 argued that a dynamic best-before date potentially will create less wastage as consumers may have more time to consumer the product. Yet, if the indicators are implemented, all consumers argued that it is not demanded from a consumer perspective and will likely not be among the main criteria influencing the choice of grocery store to purchase at. While the consumers were generally positive towards an implementation, **I**1 cautioned that if the interest from consumers regarding solutions to improve quality and sustainability is overrated, then an implementation would be redundant.

5.3.3 Application of TTIs

The majority of the interviewees suggested that an implementation of TTIs would probably be most useful and advantageous if consumers could utilise the technology; hence, advocated for the indicators to be implemented on individual consumer packages. **I**2 argued "*I believe that [TTIs] would generate a rapid quality improvement at the consumer level, thus an [improved] understanding of quality*". **I**7 drew a parallel to food wastage "*If your aim is to have a genuine effect on food wastage, then it [an implementation] should be all the way to the consumer"*. **I**12 agreed with **I**7 and added "*A lot can happen during our consumers' transportation of their fresh goods [to their households]*". In contrast, **I**1 and **I**10 claimed that an implementation of TTIs on pallets or cases would be sufficient if the aim is to indicate a secure cold chain.

While the majority of interviewees at Coop along with **I**7 and **I**10 stated that the cold chain is intact from producer to store, the suppliers of indicators claimed the opposite. "*We consider our technology to be a certain and honest way to control cold chains ... We have made*

extensive temperature controls and what we have found is that temperature issues often lie at store level" (**I**14). **I**15 elaborated on the same issue "*Once in a while there is a tendency [by stores] to create like a sales tool, to show that they have a lot of merchandise, and [when doing so] the products at the top are basically placed in room temperature*". **I**5 expressed the importance with performing extensive tests and follow-up before implementing TTIs and another interviewee, **I**6, suggested to execute an implementation of TTIs through dividing it into two steps. The first step, according to **I**6, would be to use TTIs up to point of retail to get control over current processes and certify that the cold chain is intact. Then, the next step would be to implement TTIs all the way to the consumer and thereby be able to provide them with dynamic best-before dates.

5.4 Communication

5.4.1 Internal understanding

In general, there was a consensus among the interviewees that handling perishable products in a correct manner requires a certain skill, knowledge and understanding. These aspects were deemed as a prerequisite for the personnel to manage having intact cold chains and maintaining high quality products. Here, it is important that the staff understands the purpose of why quality systems are in place and the reason for performing quality checks, according to **I**11.

When discussing a potential implementation of indicators, **I**12 stated *"Everyone needs to be aware of the purpose with these labels. I do not think it is possible to just start, prior to it you have to inform that this is the way it is"*. Consequently, **I**12 argued that an implementation requires a large amount of training of the personnel both to create understanding but also to establish processes for their usage. **I**2 added "*over time I believe this will help stores, but initially there might be a problem before the store personnel have learned how to handle the indicators"*. In connection to the internal understanding of the food chain, **I**1 discussed the receptivity of the food industry, suggesting that previously there has been an unawareness and disinterest from the market concerning TTIs, which also may pose a risk to the technology.

5.4.2 Educating consumers

During the discussions regarding food quality and handling of products, the supply chain actors and the Coop interviewees argued that generally there is a high ignorance and unawareness among consumers concerning these topics. For example, **I**1 argued that people are not aware of that best-before dates have a high margin for error: thus, the products are normally edible for a longer period than stated on the label. The perception of a lack of knowledge and awareness among consumers was shared by the participants in the focus group, which implied that there is an ignorance regarding the quality risks of perishables.

Additionally, the consumers argued that companies are not supplying sufficient information. **F**2 argued *"information regarding handling is only provided when something has gone wrong"* and **F**1 continued *"and only a little bit later when you might already have eaten the product"*. Yet, consumers are getting increasingly more aware and have higher demands on the supply chain and its actors in terms of handling, quality, hygiene, sustainability, and traceability, according to **I**5. The same interviewee argued that this requires the actors to improve the communication and information directed towards the consumers and explain why better handling and quality generates higher product prices.

The majority of the interviewees argued that one way of how to tackle this issue is by educating consumers. **I**5 expressed *"we try to focus on providing consumers with information, sharing knowledge, advising on what to make for dinner and how they can decrease their food wastage, and so forth"*. **I**7 argued in line with previous argument and claimed *"I believe that you have to educate, raise awareness and inform consumers during a long time before it would make any relevance to implement TTIs"*, specifically emphasising consumers' desire to purchase fresh products. In turn, a supplier of TTIs argued that their technology can make a difference "*We waste food at production, at store level and at consumer level. What our product does is that it takes away this uncertainty, and brings certainty*" (**I**15). The interviewee elaborated that with this technology *"retailers can give their consumers a tool to try to reduce and avoid food wastage"*.

I1 believed that an implementation can raise awareness and initiate reflection amongst consumers, as well as educate them regarding food and how quality is affected. The interviewee stated *"Hopefully, it becomes a hot topic, that people are talking about this and discuss at their kitchen table. That the steak was a week old based on the best-before date but it was editable anyway. It would be great if it could lead to that kind of reflections and discussions"* (**I**1). A crucial aspect is to change the behaviour of consumers, according to **I**7. The interviewee continued with arguing that consumers need to quit blindly relying on expiration dates and stop selecting the freshest product in store, in spite of that the food is going to be consumed the same day.

5.4.3 Marketing management

The issues of how to inform, educate and communicate to internal personnel and consumers concerning food handling, wastage and indicators were recurring subjects throughout the majority of the interviews with Coop employees. **I**5 emphasised that *"... you need to structure and communicate in a way so it is clear, both internally and externally, that we are working towards certain goals"*. The communication towards consumers was seen as especially difficult by most of the interviewees and **I**13 stated that it is a challenge to reach consumers of different generations while creating a common understanding for why food handling and sustainability are important issues.

Simplicity, pedagogy and visual aspects were mentioned by **I**1 and **I**5, as well as by the consumers and a supplier of indicators (**I**15), as important elements when communicating to facilitate increased awareness among consumers. *"Primarily, it is important that it [the indicator] is clear to the customer"* said **I**1 and explained that customers should be able to easily determine the shelf life of the product. Also, the information and increased understanding should not generate a higher uncertainty for consumers regarding the safety of food products or create additional food wastage. **I**5 explained: *"It needs to be experienced as a very positive thing when communicating. It is a thin line between how much information you can receive. It is not always the case that more information creates trust and a positive shopping experience for the consumer; information can also be counterproductive"*.

An indicator increases the transparency regarding the handling of food product throughout the supply chain, which can show both supply chain actors and consumers that the products are of high quality, or of poor handling and consequently poor quality, according to **I**11. **I**12 also mentioned that it increases the retailer's honesty. The indicators are by several interviewees primarily regarded as a tool targeted towards the consumers. **I**6 discussed that the indicators are a customer offering, which may influence the purchasing behaviour of consumers and contribute to building the brand of the retailer. This argument was similarly mentioned by **I**15 being one of the suppliers of the indicators.

From a consumer perspective, communication between retailers and consumers was deemed important to increase the knowledge of consumers and inform about quality risks. During the discussion regarding indicators, the consumers emphasised simplicity and the visual aspects of the indicator and argued that the communication needs to be pedagogical and that the indicator should be easily read and understandable. Similarly, for an implementation to be welcomed by consumers **F**5 stated *"It [an implementation] requires that you know what it is. That you have informed the customers and encouraged them to look for it"*. Overall, the communication with consumers was regarded as highly influential for the future success of a potential implementation among both interviewees and consumers. **I**2 stated *"In the long run, with the right marketing supporting this, I believe that it is possible to establish trust among our consumers as we guarantee that we don't sell products with insufficient quality and, at the same time, we help consumers to keep track of the expiration of products in order to not cause unnecessary food wastage."*

5.5 Future

During the discussions on quality, food wastage and a potential implementation of TTIs, several interviewees expressed their thoughts regarding the future development of the food industry, as well as the future of TTIs in the grocery retail sector. **I**5 explained that consumers will become increasingly aware of quality, traceability and sustainability aspects connected to the food purchased and **I**1 stated that the cold chain will likely be put in the limelight to a

greater extent. **I**2 indicated that effort needs to be directed towards educating the consumers on how to handle food products properly in the near future.

Regarding the future of the indicators, **I**12 stated *"I believe that if one starts, many others will follow"*. As the societal trends moves towards increased control of the chain, **I**6 argued *"if we do not join in, then in 10 years we will have fallen behind"*. **I**1 was more hesitant and mentioned that the indicators may applied on some products in the future, primarily meat products and salmon, but far from being on every package. An interviewee (**I**11) suggested an alternative thought regarding the future of TTIs "*I think it would be a great idea if indicators were to become a legal requirement so everyone would use it, because then the general quality standard [of food products] in Sweden would increase*". The suppliers of the indicators (**I**14 and **I**15) were optimistic about the future of the technology and positive of the fact that the indicators will be on a wide range of product categories, as well as present in multiple supply chains. Both suppliers of TTIs, and **I**2 mentioned that the technology could be implemented on other perishable products in the future. **I**1 argued that if large retail chains started to implement the technology it will reduce the costs and likely improve the technology *"it will probably be more digitally connected"*.

The consumers shared the optimism for the future of the indicators arguing that it is coherent with the current trends emphasising health and sustainability. All the consumers predicted the use of the technology to become extensive in the upcoming years and that it would likely be adopted by all the major retailers if initiated on the market. Additionally, during the focus group interview, the **F**5 and **F**2 saw opportunities for the restaurants and the home delivered grocery business to implement the indicators as a method to ensure quality for their customers. Yet, **F**2 pointed out that for the technology to be able to successfully enter the market *"it needs to be a product that is thought through and that is actually working. There can be no mistakes in the upcoming years, because then the trust is broken"*.

5.6 Summary

To conclude, the themes 'quality', 'efficiency', 'implementation', 'communication' and 'future' emerged from the data gathered. Food quality appeared to be closely related to processes at producer all the way to stores and was highly emphasised throughout the discussion by both interviewees and participants. In turn, quality risks were often associated with these processes and the current way of working, as well as lack of knowledge by personnel and consumers. However, the majority of the mishandling of perishable food was identified at the consumer stage, which also was seen as the main contributor to food wastage among the interviewees. While quality is of great significance, efficiency related to the issues of time pressure, cost and food wastage were discussed as factors influencing the handling and quality of food products.

Table 3. Summary of benefits and risks based on the empirical result

Implementation of TTIs	
Benefits	**Risks**
Supply chain actors	
Efficient control	Limited traceability
Dynamic best-before date	Novel technology
First mover advantage	Technological limitations
Increased awareness	Resource consuming
Right in time	Not useful for all actors
Increased food safety	Too reliant on technology
Minimise human error	Economic loss due to less production
Inventory system	No effect on initial meat quality
Improved quality of products	
Goodwill	
Transparency	
Improved quality processes at store	
Consumers	
Improved food quality	Price increase
Improved food safety	Uncertainty
Visual shelf-life	Increased food wastage
Shelf-life precision	Not main purchasing criteria
Improved handling at home	Decreased trust if insufficient cold chain
Increased retailer trust	
Competitive advantage	
Decreased food wastage	

When elaborating on a potential implementation of TTIs the discussions clearly highlighted the main benefits and risk associated with the technology. To summarise these, Table 3 highlights the main findings from all interviewees and the focus group. Furthermore, internal and external communication also seemed to be closely related to the success of an implementation, which brought topics such as internal understanding, marketing management and educating consumers. Finally, both interviewees and focus group participants elaborated on future thoughts regarding TTIs.

6. Analysis

In this section, the theory gathered is contrasted against the empirical interpretations made and the identified themes and categories, which compounds in a research analysis. The chapter elaborates on the research questions where the aim is to provide a clear picture of the topic in the context of a Swedish grocery retail chain.

The chapter is divided into four main sections; supply chain requirements, technological aspects, implementation, and future. Firstly, the analysis discusses whether a solution for improving quality, traceability and sustainability in the meat supply chain is needed. Secondly, technological aspects address the functionalities and limitations of TTIs in order to establish its potential. Furthermore, the implementation section scrutinises the impact TTIs could have on quality management, sustainability and food wastage, consumers, resource management, and the competitiveness of the retailer, as well as addresses the scope of a potential implementation. Finally, the future prospects of the technology are discussed.

6.1 Supply chain requirements

The necessity of managing quality in food supply chains was strikingly evident when conducting the individual and focus group interviews, as well as in the academic literature. The perishable nature of meat and the risks inherent with the product characteristics appeared to significantly influence the operation of the supply chain and was closely linked to supply chain performance, as similarly mentioned by van der Vorst et al. (2009). Additionally, traceability focusing on the significance of temperature and correct handling of sensitive products throughout the chain were addressed as prerequisites for the health and safety of consumers by several of the interviewees and by Olsson and Skjöldebrand (2008). From a consumer perspective, food quality and safety are critical and with increasing consumer awareness, mentioned by the Sustainability Strategist (**I**5) and focus group participants, growing pressure is placed on the supply chain to produce safe food. Retailers are increasingly held accountable for deficiencies in the supply chain (Seuring & Müller, 2008) and the consumers stated that potential scandals significantly influence their perception of the grocery retailer or food brand; thus, reduce sales. Hence, it becomes even more important to guarantee the safety and quality by ensuring traceability for all products reaching the hands of the consumers. Yet, a cost focus was evident during the coding process as it was mentioned by several interviewees to be prominent in the industry at all stages in the chain, including the consumer level. Auler et al. (2016) similarly stated that the pressure from external stakeholders to lower costs may force retailers to neglect to prioritise food quality.

The connection drawn by Raab et al. (2011) and the interviewees between the handling of products at each actor and the success of the supply chain is realistic, since the management of goods directly affects the consumers and the amount of wastage produced. The handling of food influences the consumer perception of the brand and the sales generated, as well as the

cost produced. Consequently, traceability and quality management need to be among the top priorities for a food supply chain in order to stay competitive while still being cost conscious. Thus, there is constantly a need to ensure proper management and food quality in the supply chain, as well as for reducing the deficiencies and minimising the risks of compromising consumer health.

6.1.1 Quality Processes

The interviewees at Coop and the external actors in the meat supply chain clearly indicated that the quality processes were sufficient to ensure an intact cold chain and thereby also safe products for their consumers. While Coop is certain of the proper handling of goods in their chains, the interviewees at Coop were open about the fact that there are always risks present in supply chains that needs to be considered and managed. The interviewees identified risks for all supply chain actors, in conformance to literature (e.g. Olsson & Skjöldebrand, 2008), but often overlooked the risk present in between actors, including goods standing at loading docks for too long. Thus, neglecting significant risks that could impact meat quality, as implied by Olsson and Skjöldebrand (2008). Instead the identified risks were related to slow thermometers when performing spot-checks and the inability to determine the historical handling of the products. Additionally, the interviewees mentioned that human errors were among the primary risks, since it is difficult to avoid individuals making mistakes.

Based on these risks, the actors can never be entirely certain that each consumer package has been handled correctly at all times by all actors, and in between actors, since the checks are not performed on every package and cannot indicate how the product has been handled prior to the temperature control. Similarly, while quality processes and training are established at each stage in the chain, there is never complete certainty that the personnel is knowledgeable or is performing the processes correctly, or even at all. The time aspect increases the risks even more as, for example, transport personnel are often under pressure to distribute the products quickly and store personnel need to prioritise between restocking the shelves at store or leaving the products on the floor to attend the cash register and serve customers. Moreover, for retailers sourcing products from longer distances the number of actors often increase, which complicates the issues of maintaining quality, ensuring the correct handling of perishables, and diminishes the possibility to follow-up on quality processes.

6.1.2 Manage end-to-end control

Extended supply chains with an increasing number of actors creates difficulties to maintain control and increases quality risks for perishable meat products. To have control and ensure food quality through all stages of the supply chain is crucial; thus, requires integration and coordination between actors, according to van der Vorst et al. (2009), and Lambert and Cooper (2000). Scandals in the food industry, both in terms of traceability and quality, can significantly affect the perception by consumers and other stakeholders, as evident from the

focus group interview and argued for by Olsen and Borit (2013). Thus, it is important to ensure food quality and traceability during all stages of the chain, as well as to facilitate information sharing.

While supply chain control was rarely specifically mentioned in the interviews with the interviewees, it was evident during the coding process that the issue of how to maintain quality throughout the supply chain was highly relevant. Coordination and integration between actors appeared to be vital and lack of information from actors in the chain could be problematic as it creates both quality and traceability issues. The current method for controlling quality in terms of temperature in the Swedish food industry, using spot checks at the products' arrival at each actor, may have implications on food quality and traceability in the chain. Today, each actor is reliant on correct handling of the products by the previous actors in the chain, without always having the ability to control if that is the case. In the event that one actor does not fulfil their commitment it affects the quality of the product regardless of the handling of the subsequent actors in the supply chain, and ultimately affects the consumers.

Hence, it was argued by the Head of Quality at Coop (**I**1) that it is important to facilitate traceability for grocery products and have methods for ensuring quality in the entire chain. The focus group participants argued that consumers currently lack information about how the products have been handled; thus, part of the chain is left in the dark regarding issues which may ultimately result in serious consequences for consumer health. In consistency to this, the idea of traceability from 'farm to fork' is addressed in literature, arguing for increased information sharing and traceability along the chain. Mazini and Accorsi (2013) specifically argue that the consumer stage is ignored when discussing the issue of traceability and food quality. As consumers are becoming more aware, the need for businesses to provide more information to stakeholders and to integrate consumers in the supply chain concept will increase. Thus, the retailers and supply chain actors need to have methods for how to provide information and ensure quality to other actors in the chain and to the consumers.

6.1.3 Sustainability

While retailers face stakeholder pressure to guarantee the quality and traceability of products, Scheifer (2002) and the majority of the interviewees at Coop have also indicated a growing pressure on grocery retailers and society as a whole to embrace sustainable approaches. The emphasis in literature has focused on the current rate of overconsumption (Marinova & Raven, 2006) and the issue of food wastage has gained increasing attention in recent years. Inefficient supply chains have been identified by both Parfitt et al. (2010) and practise to cause unnecessary wastage and in turn economic losses for consumers. Inefficient processes and systems in the chain, from producer to store, has been pinpointed by the interviewees at Coop as contributors to unnecessary production and wastage. Yet, both Kummu et al. (2012) and practise arrive at the same conclusion; the common denominator of the issue of food

wastage is the consumer, which likewise is in compliance with statistics presented by Naturvårdsverket (2014). Significant contributors to wastage at consumer level appeared to be lack of planning and lack of knowledge regarding best-before dates, determining food quality and proper management of food, which conform with research by Parfitt et al. (2010). Thus, it is clear that efforts need to be directed towards the consumers in order to effectively decrease the overproduction and minimise the food wastage in general.

Similarly, sustainability issues were mentioned by the consumers in terms of purchasing organic products and food wastage. The lack of knowledge among consumers in general was likewise mentioned by the focus group participants to be contributing to wastage and it was evident that some consumers are unaware or does not reflect on how to handle food properly. When asking about how the consumers handle food at home, the answers were solely focusing on putting the perishables in the refrigerator quickly, while there was no evidence of reflection after this point. For example, insufficient temperature in fridges, food left out to thaw for too long, and temperature fluctuations are known to negatively affect the quality of perishable products, but was not considered by the consumers. Hence, to minimise wastage attention needs to be brought to the handling of products at home, but also in store and during transportation, as well as educate how a best-before date should be interpreted. Since the consumers themselves claim to be negatively affected emotionally by wastage and would benefit financially from throwing away less food and, it appears as if a solution to prevent waste at the consumer stage would be welcomed. Yet, regarding raw meat products the issue of wastage is less prominent, partly due to meat products generally being more expensive and therefore less subjected to disposal by the interviewed consumers.

Even though compliance exist between theory and practise regarding food wastage and overproduction being significant problems, the question of how to tackle these issues still remains. Since as much as 20% of the food produced in the EU is lost or wasted before and after it reaches the consumer (Stenmarck et al., 2016) it is evident that society and the industry should beg for solutions to prevent or at least minimise food wastage. Yet, despite overproduction and food wastage being portrayed in both literature and by the majority of the interviewees and consumers as an issue that needs to be managed and minimised, **I**1 involved in the quality management at Coop argued that the society desires food wastage. The claim that the society would be averse to reduced production and wastage is not unrealistic as it would significantly affect the profitability of farmers, and potentially put some out of business, as well as result in less business for all actors in the chain. For consumers, it would require them to not have perishable food products at home as a back-up plan for unexpected situations, which is simply disposed of if not utilised. However, these sacrifices may be necessary to achieve a more sustainable consumption and minimise the damaging effects on the environment; yet, the question arises whether the society truly regard food wastage as a negative phenomenon.

6.1.4 Need for a new solution?

When reviewing the literature and the result from the coding, food quality is high on the agenda, and more accurate and secure methods for ensuring the quality of perishable products is welcomed by the industry; but, only to a certain cost. The pressure from external stakeholders for low prices has generated narrow margins and a strong emphasis on cost throughout the industry. Therefore, any new innovations must be profitable financially in the long run for the supply chain, as well as not generate large additional costs for the consumers in order to be successful. Yet, it is clear that a solution to minimise human errors and secure the quality of each individual product could further improve the already high quality of food products in the Swedish food industry.

Additionally, there are indications of a demand, from both industry and consumers, for a more dynamic alternative to the printed best-before date. The current method for indicating remaining shelf life has clear limitations since the static date often indicate a too low shelf life for properly handled perishables, while it does not adapt to temperature abused products. Thus, it cannot always be regarded as an accurate indication of product shelf life, as similarly concluded by Verghese et al. (2015). Furthermore, the lack of consumer knowledge regarding best-before dates and handling of products cause significant amounts of food wastage each year. Hence, if the aim is to manage this issue, the consumers need a helping hand. Yet, the demand for such a solution did not appear to be great when discussing the matter during the focus group interview. The consumers stated that they wanted to decrease their wastage but, similarly to the industry actors, it was a question of price. Further, the consumers stated that they did not currently see a need for any solution for reducing their wastage and improve food handling; instead they required more information from the retailers and education of consumers regarding these issues. Similarly, the question remains regarding whether the industry and consumers truly desire reductions in overproduction and food wastage.

Despite the high pressure on production, distribution and retail in the food industry with strict demands on quality, traceability and sustainability of the operations, these pressures are expected by both academics, industry actors and consumers to increase even further in the future. Thus, the search and initiation of a solution to indicate cold chain breakage may be profitable in the long run as a proactive initiative since stricter regulations in the future may demand proof of intact cold chains. Additionally, while it does not currently appear to be a demand for implementing these types of solutions all the way to consumers, the possibility exist that a demand will be created if it is launched on the market. After all, few people demand a technology they have no knowledge or experience of. Subsequently, by creating a demand among consumers it often creates a demand further upstream in the supply chain.

6.2 Technological aspects

The primary emphasis in this thesis is time-temperature indicators, specifically focusing on two different categories of the technology: TTI A indicating whether a temperature breakage has occurred by destroying the EAN barcode, and TTI B which integrates time and temperature to simulate the remaining shelf life of the product. Both indicators have several functions providing benefits to the supply chain, but there are also factors limiting the technology.

6.2.1 Function of TTIs

Generally, TTIs are used as tools to indicate whether the cold chain has stayed intact or if there at some point has occurred a temperature abuse of the product that has affected the shelf life or made the product unfit for consumption. The advantages brought by this function is addressed by multiple researchers, including Realini and Marcos (2014), Lu et al. (2013), and Taoukis and Labuza (1989). Likewise, the coding revealed benefits connected to the possibility to indicate potential cold chain breakage. Both the interview participants and academics mentioned the possibility to indicate quality and increase the traceability of the products through receiving information regarding whether the product has been handled correctly. Specifically, both suppliers of TTI A and TTI B argued for improved control throughout the chain as the technologies provide possibility to access information regarding the cold chain of the unit level it is attached to. Similarly, the benefits highlighted by the quality managers at Coop and in store included increased control for individual packages and the possibility to guarantee an intact cold chain, and thereby the quality of the meat. **I**1 and **I**10, involved in quality management and transportation of perishables, mentioned that the TTIs could potentially be utilised to perform quality checks on incoming pallets from producer to store.

Among the main benefits identified by both Realini and Marcos (2014) and Sahin et al. (2007), as well as in practice was the possibility to have a dynamic best-before date that adapt the remaining shelf life of the meat product based on the temperature history, such as TTI B. The possibility to indirectly indicate shelf life of a product could more accurately indicate when a food product is safe to consume, given correct settings of the TTIs. In turn, this may prolong the shelf life compared to the static date stamp providing more time for the product to be consumed and therefore potentially reduce food wastage. These conclusions regarding the possibility of packaging to minimise wastage were supported by Verghese et al. (2015) and Realini and Marcos (2014). However, if the TTIs would show evidence of cold chain breaks that would otherwise gone unnoticed, the wastage would increase which in turn creates losses for the actor. This scenario may be viewed negatively from a financial perspective as profit is lost; yet, it prevents hazardous products to be consumed and reduces the risks to consumer health. Thus, indications of disruptions should be viewed as beneficial

from a consumer perspective, as well as from a retail perspective since it may minimise quality complaints.

Furthermore, the indicators were regarded by several interviewees at Coop and the focus group participants as a useful tool for educating consumers. Since the indicators can display disruptions in the cold chain, the interviewees argued that the technology could help raise awareness and that consumers could learn in what circumstances their handling of perishable meat products resulted in abuse of the products. While this may certainly be the case, it should be noted that the technology has not yet been extensively tested on consumers or proven to have an effect on consumer knowledge or their behaviour. Similarly, to the knowledge of the researchers of this thesis, there have not been any investigations conducted examining if and to what extent TTIs can affect food wastage in the chain and at consumer level. Nonetheless, both Realini and Marcos (2014) and the interviewees at Coop were positive regarding TTIs effect on food wastage.

6.2.2 TTI limitations

When looking at different TTIs objectively, the common function is to monitor and indicate temperature abuse in food supply chains. While the technology has several benefits, as claimed by the suppliers of indicators and noted by the majority of the interviewees, there are limitations inherent in the technology as well.

During the interviews, both the suppliers of TTI A and TTI B claimed that the technology is able to increase certainty of proper handling within supply chains and reveal if fresh food products have been abused. Furthermore, the main idea of the technology is to improve and simplify quality controls within food supply chains; but this may not always be the case. Due to the design of the technology, the indicator can tell whether a temperature breakage has occurred, however, not during which point in time. If several fluctuations in temperature occurred at previous actors, it would not be directly evident from the information provided by the TTIs who is responsible for the disruption. Consequently, additional methods for recording temperature history would still be required to determine the origin of the breakage and TTIs would not necessarily simplify temperature control. The lack of standardised methods for traceability control have resulted in actors using different methods for tracking products. As some actors may use EAN barcodes as a traceability tool, the destruction of these codes might significantly obstruct the current way of tracking and tracing products.

Critique has further been targeted at the technology for being rather analogue. In theory, researchers have argued for the possibility of TTIs to monitor and record temperature along the supply chain (Taoukis & Labuza, 1989). Despite of this, the Head of Quality (**I**1) argued that the technology is too analogue for it to be efficient to collect and save information from the TTIs. To record the information would require additional workload to transfer the information manually from the indicator to a computer in order to increase the accessibility of

it. Hence, it would be too time consuming for it to be feasible in the long run. Furthermore, the removability of the labels was mistrusted by the consumers due to the possibility to tamper with them, mentioned by both the focus group participants and Pennanen et al. (2015). The focus group participants argued that if the retailer was trustworthy this would not be an issue.

Moreover, the suppliers of indicators guarantee a 100% certainty regarding the accuracy of the technology, assuring it can be completely trusted. The underlying reason for such a promise is based on extensive tests performed during a long time period. Due to the seriousness of food safety, the indicators need to have a high accuracy to not endanger consumers. In spite of this, it is important to mention that there is always a risk for error; hence, ensuring complete accuracy of a technology can always be questioned. Moreover, for suppliers to be able to guarantee an intact cold chain and ensure accuracy of the simulated shelf life, it is required that the initial meat quality is known and sufficient, as suggested by Heising et al. (2014). Yet, this can neither be verified nor monitored by the TTIs since they are applied at production. Instead, the accuracy of the technology is dependent on the producer performing tests of initial quality of the meat, which clearly is a limitation with the indicators. Therefore, the concept and success of TTIs is built upon collaboration and integration permeating the entire supply chain.

While the initial quality of meat can influence the shelf life of the product, TTIs in isolation cannot. TTIs combining time and temperature to simulate remaining shelf life only provides a more accurate indication of the expiration of the product while not directly impacting the product quality. This to some extent contradicts the statement by the supplier of TTI B (I15), who imposed a strong argument for how the technology can extend the current shelf life of a product. However, the TTI can generate other effects that can influence quality.

Furthermore, the suppliers of TTIs claimed to have a positive effect on food wastage by providing a more correct indication of best-before dates, which enables for fresh products to be sold and consumed for a longer period. Yet, by simply applying the TTI to the package will not automatically have an impact on food wastage. To have an effect on food wastage there are likely other vital aspects that need to be considered in addition to the application, including communication and education of personnel and external stakeholders, and improved quality processes.

6.3 A potential implementation of TTIs

Depending on the indicators technological functions and their main purpose, the indicators are more or less applicable for various scenarios. Hence, the advantages and disadvantages of various indicators depend on the both the technology itself, but also on the purpose with an implementation from a retailer perspective.

6.3.1 Quality assurance

In accordance with theory and the results from the coding, to guarantee the quality of fresh products is essential for grocery retailers. Likewise, visibility, traceability and proper control to ensure food safety by facilitating tracking of products are argued to be fundamental for cold chain performance (Ringsberg, 2014; Bogataj et al., 2005). Today, there is a general agreement that there is a need for organisational collaboration and efficient information management between actors to be able to maintain an intact food chain; thus, there needs to be a responsibility regarding temperature control permeating the entire chain. Furthermore, food supply chains should provide stakeholders with adequate information of relevance concerning the product (Bosona & Gebresenbet, 2013). These requirements can be argued to not have been met since the actors are reliant on trust and the interviewed consumers feel uninformed regarding temperature handling of food products along the supply chain. Perhaps the latter is a result from the fact that consumers are often overlooked when considering traceability in supply chains (Aung & Chang, 2014). Both academia (Taoukis & Labuza, 1989), the Coop interviewees and naturally the suppliers of indicators considered TTIs to be a traceability tool for ensuring this. In addition, the indicators provide the possibility to detect temperature risks, such as critical points in between actors in the supply chain which previously have been overlooked.

To be able to trace temperature abuse further back in the chain was deemed desirable by the majority of the supply chain actors, as this control is limited today. As imposed by the EC (178/2002), actors are required to ensure food quality, but the decision of how to manage traceability is up to each individual actor. This have resulted in actors using different control tools and systems when tracing products, which drastically obstructs the traceability. There was a general agreement among the interviewees that traceability would increase if TTIs were implemented since the indicators can display previous temperature abuse in the chain. Despite this, the function can also pose risks. The purchaser and category developer (I3) argued that a cold chain can be kept intact from producer to store, but ruined by the consumer while shopping. Then the economic loss and damage on reputation would still befall the retailer, although the consumer being the weak link. Furthermore, as TTIs do not have the ability to control traceability related to origin or point of abuse, the control would still be constrained in spite of an implementation.

Moreover, an implementation of TTIs in Swedish food supply chains needs to be carefully thought through before taken into action. As TTIs has been claimed to be a rather analogue technique, it may be unsuitable to use as a tool to monitor if cold chains are intact on a larger scale. This is mainly due to the difficulty to establish a comprehensive understanding and control if no information is saved digitally, as similarly argued by the Head of Quality (**I**1). However, the technology can be appropriate for other purposes. Hence, retailers need to consider how to utilise the technology with its current qualifications and thereby also take

into account the extensive work of having to translate this into digital information or otherwise consider choosing a more digitalised version of the technology.

Today, there are alternative TTIs which are digitally integrated, for example through using RFID, as mentioned by Herbon et al. (2014). These TTIs send information about the temperature of each package, simplifying the handling procedure drastically during distribution by not having to unload entire pallets to check temperature on the packages, which would be the case for analogue TTIs if wanting to control each unit. Yet, the technology is more expensive than the versions investigated within this thesis; thus, a cost analysis is needed determining its feasibility. Furthermore, as these digital technologies produce extensive amounts of data, a plan for how to handle such information is required.

6.3.2 Quality effects along the chain

The quality benefits associated with implementing TTIs in meat supply chains were questioned by the interviewees and the opinions differed depending on the extent of the implementation and on the actor's position in the chain. At production level, for instance, **I**7 argued that TTIs could not be utilised for quality assurance as the technology is activated at packaging; instead, the producer has its own methods for managing quality control before the meat is packed. This argument pinpoints TTIs inability to determine initial quality of fresh products or indicate temperature breakage before packaging. The distributors, in turn, discussed in line with the producer since they likewise do not handle individual consumer packages and thereby would not be able to utilise the TTI if implemented on each individual package. According to Sahin et al. (2007) and the suppliers of TTIs, the indicators can also be implemented on pallet or case, which could be utilised at quality control at terminal. What is important to consider is that such an implementation would not cover for temperature variations within pallets since TTIs solely control temperature at one particular spot.

Yet, the majority of the interviewees saw great potential for TTIs as a tool for logistics management at store level. While literature lacks extensive research within the field of implementation, the interviewees argued that improved processes, handling and quality knowledge among store personnel would be beneficial with an implementation of TTIs. Furthermore, the possibility to implement an inventory management system using least shelf life remaining first out (LSFO) as an alternative to FIFO, has been identified by Sahin et al. (2007). An LSFO system would enable for stores to increase profit and minimise wastage as products with short shelf life would be stocked up front, and thereby improve the stock rotation. On the other hand, it is also likely that the LSFO would replace the current system without generating any significant improvements, especially if the cold chain is intact. Similarly, while it was argued that TTIs can improve the knowledge of store personnel, relying too much on the technology to indicate safe products may result in loss of valuable expertise among the personnel and can pose risks if the indicator is inaccurate.

Furthermore, price reductions for products with short remaining shelf life could be based on the information provided by the indicator rather than the printed date stamp. According to the supplier of TTI B, this would be beneficial for both retailers and consumers since the products can be sold after the expiration of the printed date stamp, given correct handling, while consumers are offered a better price and food wastage is avoided. Currently, the Swedish law allows sales to be made after the expiration of the printed best-before date if the quality can be guaranteed; but this is not applied in practice due to the uncertainty of product quality. Moreover, price reductions have been criticised by Eriksson and Strid (2013) for contributing to economic loss for stores, whilst it can be argued that price reductions are preferable to wasting food.

Despite TTIs providing the possibility to guarantee product quality after the expiration of the best-before date, the consumers still purchase the products with the longest remaining shelf life at store. The interviewed consumers claimed that they tend to avoid groceries with price reductions since they prefer to buy the freshest products in store. Price reductions would most likely remain the same principle with the only difference being consumers selecting products based on the indicators instead of the static date stamp. Thus, offering discounted products with indicators will not make a significant difference, which puts the problem of food wastage at stores back to square one. Moreover, the products sold to a discounted price may still be wasted at consumer level, an argument which was confirmed by the majority of the interviewees. Although, it is important to highlight that consumers having a stricter budget might be more susceptible to price reductions of perishable products. Additionally, the indicators do provide the possibility for stores to have products longer in stock for products that have been properly handled and thereby increase the opportunity for sales. Yet, it should be mentioned that this is not applicable to all meat products since some are labelled with use-by dates and can therefore not be sold legally after this date. Additionally, Head of Quality (**I**1) argued that application of TTIs may be unsuitable for highly sensitive products, such as minced meat, since it could endanger consumer health if the indicator is not completely accurate.

6.3.3 A sustainable solution?

Sustainability as a concept have evolved over time and is today a natural part of firms' operations, which likewise is the case at Coop. In line with the TBL definition by Elkington (1997), several interviewees at Coop agreed on that social and environmental considerations are beginning to receive the same attention as financial aspects within businesses. When discussing the reasons for the rising interest, the explanation was in compliance with theory itself: increased pressure from external interest groups (Scheifer, 2002). How to handle increasing pressure is known to be challenging; yet, crucial for firms. At Coop, these pressures are managed by combining financial management activities with a strong environmental and social sustainability profile that permeates the entire organisation. Even though Coop is aware of the importance of the TBL, the majority of the interviewees at Coop

agreed that these activities can always be improved. Hence, with a sustainability focus that is expected to increase in size and an uncontrolled food wastage occurring on a daily basis in food supply chains, an implementation of TTIs as a sustainability initiative would conform to the current and future development of the company, the food industry and the society in general.

Overall, the majority of the interviewees saw great potential in implementing TTIs in Coop's supply chain as the entire company holds a primary focus on sustainability. Since TTIs have the ability to monitor the temperature of fresh goods, all the way from producer to store or consumer, it can be argued to not only be a great sustainability initiative, but also a useful tool for how to reduce food wastage. As argued by both suppliers of TTIs, the technology helps the retailer to improve the handling at store and thereby avoid unnecessary food wastage. Realising the importance of correct temperature for fresh goods and becoming aware of proper handling were agreed by both suppliers of TTIs and interviewees at Coop to be among the main benefits of TTIs at store level. Furthermore, by exposing if a temperature breakage has occurred, the technology can further be a guarantee of food quality for the consumer, which was confirmed by the Quality Manager (**I**2).

When reviewing the results from the coding process, there was a general concern that the food wastage might increase if the TTIs reveal extensive temperature breakage in the chain. When the suppliers of TTIs (**I**14 and **I**15) were approached with this critique, they viewed the issue in another way and questioned how poor products retailers actually want to sell. If TTIs would start to reveal severe temperature breakages, which otherwise would not have been detected, it becomes evident that the wastage will increase. But this in turn would only be "necessary" wastage since the products are unsuitable for consumption. Consequently, the retailers need to ask themselves whether to prioritise making sales while potentially having a broken cold chain, or emphasising the health and safety of their consumers. In the long run, both suppliers of TTIs and the interviewees at Coop agreed that the food wastage would decrease due to improved knowledge and handling.

As generally agreed, the major contributor to food wastage is consumers, hence, a solution for how to manage food wastage at that level appeared to be of main interest by the interviewees at Coop. To be able to provide consumers with indicators visualising remaining shelf life, not only temperature breakage, such as TTI B was argued by the interviewees at Coop to be even more beneficial in terms of increased consumer trust and brand building, benefits which are confirmed by Sahin et al. (2007). Nonetheless, there are some question marks that still remain regarding this particular TTI. Consumers are known to reject food in store with short expiration dates, which creates concern if the similar issue would exist even if using TTIs. Furthermore, if stores would decrease their wastage by selling products with short remaining shelf life, the wastage might instead increase at consumer level due to inability to take care of the product before it expires. On the other hand, the suppliers of

indicators argue that these products would preferably be sold at a discounted price; hence, the consumer buying the product are aware of the short best-before date when purchasing.

6.3.4 Consumer effects

As previously stated, representatives from all stages from producer to store, as well as from Coop headquarter and the suppliers of indicators, generally argued that an implementation of TTIs should be targeted towards consumers if to have beneficial effects from a sustainability perspective. The majority requested an indicator that could be utilised by consumers at home in order to have an effect on consumers' handling of food; thus, on food wastage. Consequently, the interviewees favoured TTIs that could indicate remaining shelf life of meat at consumers' homes (such as TTI B) rather than an indicator strictly displaying whether the cold chain has stayed intact (such as TTI A).

Indications of temperature abuse are beneficial for consumers when selecting products in store and at the consumer's home since providing consumers with information regarding temperature in the supply chain can help determine if the product is safe to consume. In general, the interviewed consumers expressed trust for the Swedish grocery retailers and the handling of meat along the supply chain. Nonetheless, **F**5 argued that they are forced to trust retailers since the option would entail growing food or breeding cattle themselves. Hence, indicates that consumers do not necessarily trust the retailers, but there are currently no other feasible options for acquiring food or to assure food quality. Thus, both investigated types of TTIs may have an effect on consumers' trust towards retailers. Additionally, consumers' awareness and behaviour regarding proper handling of food could be influenced if the indicators are triggered during the transportation home or in a poorly chilled refrigerator. However, TTIs primarily indicating if the chain has stayed intact still forces consumers to rely on the best-before date if the cold chain has stayed intact. Hence, provides a limited solution to the issue of static date stamps or food wastage at the consumer stage.

Since sustainability issues are expected to receive increased attention in the future, an implementation of TTIs could be a suitable response from the retailers, especially TTI B that can minimise food wastage. The attitude towards an implementation of such an indicator was predominantly positive by consumers, who also saw great potential in using the technology themselves at home. In combination with consumers' demand for improved quality certification along with their willingness to utilise the indicator (TTI B) thereby imposes a strong argument for grocery retailers to implement this type of TTIs, as it could bring certainty to their consumers and confirm consumer trust.

The effect of TTIs on consumers in terms of becoming more sustainable can be questioned. The food disposed of at the consumer stage is resulting from expired best-before dates and poor food handling at home according to Parfitt et al. (2010). This was to some extent confirmed by the consumers, suggesting that forgotten food was among the primary causes of

wastage. The focus group participants elaborated and argued that this wastage was mainly cooked food or cheap perishable products, not meat. Additionally, fresh meat products were purchased to be consumed the same day or put in the freezer to avoid wastage. Hence, TTIs placed on fresh meat products would have limited effect on the overall food wastage, which could challenge an implementation of TTIs. Yet, an implementation on other perishable products more prone to being wasted may have an effect on the food wastage at consumer level. However, it likely becomes more vulnerable to costs added to the product price.

The general opinion of the interviewees at Coop claimed that the indicators could be a tool to influence consumer behaviour and increase awareness of temperature abuse. An implementation of TTIs was likewise argued by Head of Quality (**I**1) to provide competitive advantage to the retailer as consumers may favour stores and products utilising TTIs. In contrast, **I**7 representing the producer of meat argued that for indicators to have an effect, consumers need to be educated in order to change their purchasing behaviour and not necessarily purchase the freshest products in store. This would require extensive communication and information provided to the consumer in a simple and pedagogical manner, as expressed by the Sustainability Strategist (**I**5) and the focus group participants. Throughout the interviews there was a general agreement that communication with the consumer will be what determines the success of an implementation. Without informing the consumers about the initiative, it would likely have an undesired or no effect and thereby potentially confuse the consumers.

Similarly, the result from the focus group implied that TTIs would probably have a limited effect on consumer behaviour, both in terms of purchasing behaviour and choice of retailer and store. The implementation of TTIs will unlikely change a consumer's desire to purchase the freshest product or challenge proximity to store and price as main criterion for choice of store. Yet, for the consumers who purchase meat products with indicators the technology can potentially raise awareness of the handling at home and change consumers' view on the current date stamps. Additionally, the Head of Quality (**I**1) raised concerns regarding the potential to overrate the consumers interest in solutions to improve quality and sustainability. If that is the case, an implementation targeted towards consumers would not be effective.

6.3.5 Requirements of resources

It is evident that any implementation of a new technology or method for working will require resources by the actors involved, both in financial terms and time invested. The requirement of resources associated with an implementation of TTIs was discussed by the majority of the interviewees, arguing that it will demand significant financial investments such as machinery and training for personnel. The producer claimed that an implementation will solely impose an additional cost for a solution not adding value for them, while interviewees working close to store (**I**11-**I**13) highlighted training of store personnel to be time consuming and thereby costly. Furthermore, for an implementation to be successful it will require investments in

communication internally and towards consumers. Moreover, several interviewees elaborated on the price of each indicator and how an additional cost would be received by consumers, as the interviewees expected consumers to be charged for it. The price concern was likewise evident among the consumers, claiming that an additional cost for TTIs would be accepted, but only to a certain extent. Here, the communication will therefore be vital for educating consumers and raise awareness regarding why the technology is worth the extra cost.

When reviewing the various associations to cost, it becomes evident that, throughout the chain, there are different views on an implementation of TTIs and thereby variations in interest of the actors. Yet, an implementation of TTIs would require collaboration between actors and various departments in order to accomplish a successful implementation. Both engagement and involvement are needed from all supply chain actors ranging from producer to consumer as well as from the departments of quality, marketing, finance, purchasing, IT, SCM and HR.

Moreover, the time aspect associated with an implementation was related to both time consuming and time saving activities. To perform extensive tests and follow-up on the progress was mentioned by the Sustainability Strategist (**I**5) to be time consuming, yet required. While quality checks at store level was argued to become less time consuming due to an implementation of TTIs, the learning curve for educating store personnel was considered the opposite. Additional lead-time in already lean organisations might require to either hire more people, or make priorities since implementing new processes steal time from other vital tasks, as elaborated on by the interviewees working close to stores (**I**11-**I**13). These interviewees, however, pointed out that pressure might also increase the level of accuracy and thereby improve current operations.

In conclusion, what is important to consider is that new technologies are often more expensive at the beginning, both in terms of cost and time, as stated by the Quality Manager (**I**2). Hence, when evaluating a possible implementation, it is important to consider both short term and long term benefits and risks in order to arrive at a successful result.

6.3.6 Competitive advantage on market

To be first on the Swedish market with providing TTIs was claimed by the Quality Manager (**I**2) at Coop to be a competitive advantage. In line with an upcoming growth of food quality and traceability demands, a proactive approach could be deemed appropriate. Although several actors saw benefits with an implementation of TTIs, the quality manager explicitly mentioned a so called first mover advantage. As the Swedish grocery market is dominated by four major players, competitive tools can be expected to serve a great value, which supports the argument of **I**2. Being first, however, does not necessarily bring benefits to the first mover. A Regional Store Quality Manager (**I**11) expressed concerns regarding what would happened if it turned out that retailers overrate their cold chain management. Nonetheless,

gaining knowledge of the security and level of intactness of the cold chain is valuable to guarantee safe products and for indicating areas of improvement. In the event of a revelation of cold chain breakage, preparations for how to handle such a scenario is crucial. Yet, if cold chains were proven by TTIs to be intact, an implementation would possibly strengthen the competitive position of the retailer in relation to competitors. For instance, the focus group participants mentioned that an implementation of TTIs by one retailer could generate doubt regarding other retailers' quality processes.

An implementation of TTIs was also considered in relation to consumer demand by several interviewees. They argued that an implementation of the technology could generate an increased clientele. Despite of the optimistic outlook by the interviewees, the interviewed consumers did not display a concrete demand for TTIs; yet, they had a positive attitude towards the technology. While the focus group participants expressed this opinion, it is a limited indication of the overall consumer response to TTIs. Furthermore, it should also be noted that opinions and attitudes are not guarantees of actual behaviour. This concludes that there will always be a risk inherent to an implementation; nonetheless, nothing ventured, nothing gained. Moreover, if an implementation was made and appreciated by consumers, it would most likely generate a strong competitive advantage for the first mover.

6.3.7 Scope of implementation

To implement TTIs will likely generate both benefits and risks for retailers as mentioned in the previous sections in this chapter. The majority of the interviewees at Coop argued in favour for an implementation on consumer packages to address the sustainability issues at consumer level. However, the Head of Quality (**I**1) and the transport provider (**I**10) expressed that an implementation on pallet or case was deemed sufficient with the intention to speed up the processes at terminals. Hence, to what extent TTIs should be implemented appeared to be closely related to the purpose of the implementation. This likely results from the fact that the level of use significantly influences the benefits and risks of an implementation, as likewise mentioned by Sahin et al. (2007).

For instance, if the aim of the retailer is to decrease food wastage at store, indicators applied on consumer packages showing remaining shelf life (TTI B) can be useful for the retailer to sell the product to a discounted price when close to expiration. In contrast, indicators solely revealing temperature abuse (TTI A) would not provide this possibility. Similarly, to address food wastage at consumer level a visual indication of remaining shelf life can display to the consumer if the product is safe to consume and if it is edible shorter or longer than the printed date stamp. Hence, the former indicator (TTI B) can assure, shorten or increase shelf life compared to a printed best-before date, while the latter indicator can only assure or shorten the shelf life compared to the printed date stamp (TTI A).

If the purpose is to determine whether the cold chain is intact from producer to store, an implementation on pallets or cases is more beneficial since it can be utilised by all actors involved. Additionally, such a solution is more cost efficient as it requires less indicators. However, if implemented on pallets or cases, the indicators would not reach consumers. On the other hand, if implemented on consumer package, neither distributors nor producers will be able to utilise the indicators since they handle pallets and cases, not individual packages. Thus, if not all actors are able to utilise the technique, it is vital to investigate whether it would be beneficial for the intended purpose.

6.4 Future

During the interviews, views and opinions regarding the future development of TTIs were shared by both interviewees and focus group participants. Overall, there was a consensus that the consumer awareness in terms of quality related issues will increase in the future. As consumers demand extensive information about the quality of food products, traceability and communication upstream in food supply chains become vital factors. In addition to increased quality demands, the interviewees and focus group participants elaborated on an increased sustainability pressure on retailers, which becomes further complicated in the context of meat. It can be viewed as a critical dilemma as there is a need for meat production while it at the same time negatively affects the environment; hence, it becomes evident that a compromise between these two is required. However, if the solution to an increased awareness, as well as more sustainable production and consumption, is spelled time temperature indicators remains a question mark.

To find solutions that fit with current and future market demands is challenging, yet crucial. While grocery retailers on the Swedish market are investigating upcoming technologies for improving sustainability and food safety, actions have been implemented on a governmental level in other European countries. In France, for instance, a law targeting food wastage has made it illegal for retailers to throw away food (Carp, 2016). Hence, as the sustainability awareness increases in the society in general, a similar legislation as in France might not be far away. TTIs may be a method for supply chains and retailers themselves to fight food wastage. However, as TTIs has been claimed to be a rather analogue technique, the development of the technology has been elaborated on during the interviews focusing on its future functions and application. The interviewees commented on that integrating digitally connected technology into the TTI is the next step towards a more efficient solution. Furthermore, the technology has potential to be implemented on other product categories including other fresh food products and medicine, and in other sectors, such as the home delivery of food. Regardless of the final decision, it is clear that retailers need to consider alternative implementations and investigate its potential outcome before anything is implemented. Yet, it is evident that a solution in line with TTIs is expected in the future; thus, the question is no longer if, but when and how such an implementation will take place.

7. Conclusions

The objective of this thesis is to expand the current knowledge regarding implementations of time-temperature indicators. This section presents answers to the research questions and discusses how these findings contribute to existing theory in the field. Secondly, the practical implications of the findings are provided which can serve as a guide for future implementations by retailers. To conclude, limitations of the study and recommendations for future research are presented.

7.1 Findings and contributions

The aim of this research is to provide an assessment that can serve as a guide for a future potential implementation of time-temperature indicators in Swedish meat supply chains. The results are considered to act as an initial evaluation that can be used as a foundation for decision-making regarding an implementation of TTIs. Previous research has emphasised the technological advantages of TTIs as innovations for monitoring food quality and temperature along supply chains, while not fully considered the practical implementation of these. In this thesis, the benefits and risks associated with an implementation of TTIs have been investigated using a single case study at a Swedish grocery retailer chain. The research was initiated by performing a comprehensive literature review, which later guided the performance of the interviews and focus group discussion. Based on the literature review and the empirical findings, the analysis established that there is generally a positive attitude towards an implementation of TTIs among industry actors as well as consumers. This study can reveal that there are several benefits and risks associated with a potential implementation and that these may differ depending on the scope of the implementation and the type of technology used. Additionally, it can be concluded that the efficiency of the implementation is dependent on its purpose.

In order to fulfil the purpose of the thesis, two research questions were formulated:

1. *What are the benefits and risks associated with implementing time-temperature indicators in Swedish meat supply chains from a retailer perspective?*
2. *How can time-temperature indicators be efficiently implemented in Swedish meat supply chains?*

In order to address the first research question, a basic understanding of TTIs and the technology was required. Despite the technology not being very novel, the lack of previous research regarding implementation of TTIs was evident when conducting the literature review. Additionally, previous research neglect to examine factors associated with an implementation to the consumer stage or consider the application of TTIs from a sustainability perspective. Due to the lack of previous research within this field, this thesis can contribute with several interesting findings emphasising the associated benefits and risks.

The most interesting discoveries from the analysis were quality, sustainability, consumer and retailer related factors accompanying an implementation, as summarised in Table 4.

Table 4. Summary of benefits and risks associated with a potential implementation

Implementation of TTIs	
Benefits	**Risks**
Quality related factors	
Food safety	Revealing broken cold chains
Traceability, in terms of temperature history	Poor initial quality of fresh meat
Accurate and efficient quality processes	Analogue technology prevents record keeping
Reveal and minimise quality risks in supply chain	Less accurate if placed on pallet or case
Accurate indication of shelf-life*	Unsuitable for some products*
Increased knowledge of personnel	Loss of knowledge of personnel
	Too reliant on technology
	Incorrect settings may endanger consumer health
Sustainability related factors	
Reduced overproduction*	Increase in food wastage
Minimise wastage of edible food at store level*	No effect on overall amount of wastage
Minimise wastage of edible food at consumer level*	
Consumer related factors	
Increased awareness of proper handling	No demand from consumers
Food safety	Price sensitivity
Reduced uncertainty*	Increased uncertainty
Economic benefits*	No effect on consumer behaviour
Improved purchase planning*	Adverse to price reductions
Retailer related factors	
Inventory Management*	No effect on stock rotation*
Brand reputation	Brand reputation
Processes	Resource consuming
Supply chain control	Reveals deficiencies in chain to the public
Consumer trust	Consumer trust
Increased sales	Loss of sales
Competitiveness	First mover
Longer shelf life	
Other factors	
Transparency	Market not receptive
	Cannot be utilised by all actors in the chain

*Factors only applicable for technologies similar to TTI B implemented from producer to consumer.

The expected benefits and risks identified varied in magnitude and scope; for example, the benefit of ensuring food safety was highly regarded and more frequently addressed than the consumer benefit of improved purchase planning. Additionally, some of the benefits described cannot be exploited by the entire chain and were not considered beneficial by all actors, such as improved quality processes. Furthermore, several factors were identified as both benefits and risks due to the interviewees sharing various views of the same issue. For example, TTIs were claimed by some individuals to decrease food wastage by providing a more accurate shelf life indication, while other interviewees argued that by revealing temperature abuse the effect would be reverse. Consequently, there are factors that can be both benefits and risks depending on the initial conditions, how the technology is used and the response to an implementation.

When looking into the benefits and risks associated with a potential implementation of TTIs as a traceability and sustainability tool, it became clear that these were closely related to the purpose of the initiative. This addresses the second research question: *How can time-temperature indicators be efficiently implemented in Swedish meat supply chains?* Depending on the purpose of an implementation, there are technologies and methods for how to implement TTIs that are better suited than others. If the aim is to provide an alternative to today's printed best-before date, an indicator visualising remaining shelf life will be more appropriate than an indicator strictly indicating an occurrence of temperature abuse. Likewise, such an objective requires TTIs to be applied on individual consumer packages to be able to reach the consumers. Consequently, the purpose of a potential implementation needs to be carefully considered prior to decision making.

Based on the results from this thesis, several contributions to theory have been made. The research has examined the attitude towards an implementation of representatives from all stages in the chain, providing a comprehensive and holistic view of the issue at hand. This further contributed to expanding the knowledge regarding an implementation of TTIs from a retailer perspective and its associated benefits and risks. Moreover, the findings have broadened the existing understanding of how traceability systems such as TTIs can be used to improve quality and sustainability performance of a meat supply chain.

A lack of knowledge of consumers' perception of the technology was argued by theory to be among the primary reasons for TTIs not being implemented to a great extent as a consumer targeted initiative. Thus, through the inclusion of consumers' opinions and views, this thesis has provided insights regarding consumers' perception of TTIs, which might aid retailers in the decision-making whether to initiate an application or not. Furthermore, the choice of using a case grounded in practice has contributed to the possibility to examine the issue in a real-life context, which was noted by researchers in the field.

7.2 Practical implications

From the outset, this thesis has aimed to arrive at a conclusion that can be of relevance in a practical business context; hence, to provide a result that can guide future implementations has permeated the research process. Even though the findings can be of relevance for other industry actors, it is important to mention that they might not be completely applicable.

When implementing TTIs in food supply chains, there are several key factors to consider. First, an initial evaluation regarding the purpose of the implementation is essential. As previously stated, the aim of the implementation influences the extent of the application. Therefore, the objective needs to be carefully considered for the desired benefits to be realised. Additionally, as implied by the interviewees at Coop, different technologies are better suited for various purposes. This requires additional investigations regarding the technological options available to find the most appropriate TTI for the intended purpose. Consequently, depending on the extent of the implementation, the course of action will differ. Thus, retailers such as Coop need to evaluate which functions they require and form a strategy for how they intend to utilise the technology based on these requirements and the objective.

Furthermore, it is vital to consider the preconditions and attitudes towards an implementation of all actors involved. For instance, if the implementation extends to consumer level, to conduct investigations regarding the consumer response will be necessary to increase the understanding of consumer attitudes as well as if an actual demand exists. It should be noted that the technology has not yet been extensively tested on consumers or proven to have an effect on consumer knowledge or behaviour; thus, the consumer effect needs to be carefully considered. Moreover, if the TTIs are to be applied and marketed towards the consumer stage, it is crucial that the cold chain is intact to not jeopardise the brand reputation and consumer trust. Therefore, retailers should perform tests and follow-up on the effects along the chain to enable for the desired objectives to be realised.

An implementation further necessitates investments in communication since creating understanding for the initiative through efficient and effective communication was deemed a prerequisite for a successful implementation by the interviewees. A clear and understandable communication needs to be encouraged both internally and externally as information is key. The communication efforts should be present during all stages of the implementation to foster understanding but also to educate personnel and consumers regarding proper food handling, minimisation of wastage and the technological functions of TTIs.

Finally, if an implementation is deemed appropriate, an essential element is to continuously evaluate the progress of the implementation and response obtained from stakeholders. Therefore, retailers need a plan for how to manage this response and follow-up on the valuable inputs provided by these stakeholders. Likewise, a system for how to cope with any

potential data generated from the implementation of TTIs should be established. In conclusion, solely implementing a technology will not automatically generate the desired effects; there need to be an established course of action and research supporting such a decision. In addition, after an implementation is executed it is important to work with continuous improvements and follow-up on the effects generated by the TTIs.

7.3 Limitations and future research

While TTIs are regularly addressed in literature, the implementation of these in practice is a relatively unexplored area of research, specifically regarding application to the consumer stage. Despite that this research has included the consumer stage for an implementation to promote food quality, traceability and sustainability, previous research has often neglected consumers. Consequently, more extensive research taking consumers into consideration is needed in food supply chain research. While this thesis being a single case study, the generalisability of the results would be greater if investigations were performed using multiple cases and involved several supply chains to add to its applicability. Moreover, conducting studies on supply chains in other countries or focusing on alternative food or product categories would further expand the current knowledge in the field. As stated in this thesis, TTIs could be beneficially implemented in other product categories and markets. Hence, solely investigating fresh meat products does not fully comprehend the extent of benefits and risks associated with implementing TTIs on food products in general; however, can provide some indications.

Furthermore, as this study has taken costs into consideration, however not in a quantifiable manner, a suggestion for future research would be to look more in depth into the costs and profits associated with an implementation of TTIs to determine its financial feasibility. An alternative option would be to scrutinise other types of TTIs as there are currently a number of different technologies present on the market, and additional ones will likely be launched. Lastly, it should be noted that this thesis investigates the potential benefits and risks of an implementation since the technology is not yet in use on the Swedish market. Therefore, the possibility to examine actual effects on quality, traceability, food wastage, and consumer behaviour and attitude would significantly contribute to a more comprehensive understanding of how to implement TTIs.

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Appendices

A. Interview request sent to potential interviewees

Dear XX,

We are two students attending the master programme in logistics and transport management at the School of Business, Economics and Law at the University of Gothenburg. Currently, we are in the process of writing our master thesis in collaboration with Coop Sweden AB where we are investigating a potential implementation of time-temperature indicators in their cold chain, primarily focusing on fresh meat products. Consequently, we are examining possible benefits and risks with an implementation, as well as how these innovations would be implemented.

Since we are investigating the entire cold chain, from producer to consumer, we aim to collect information from various perspectives regarding temperature control, food safety and quality. Therefore, we kindly ask You to share Your valuable knowledge and experiences within the field by participating in an interview. The duration of the interview is expected to be approximately 45-60 minutes and will preferably be executed between the 22nd of March and the 30th of March, as we are present at the Coop headquarter in Solna during this period. Your time is highly appreciated and we are convinced that Your views and opinions will improve the results of our investigation.

If You have any questions do not hesitate to contact us for further information!

Kind regards,

Mikaela Sundström
mikaela.sundstrom@XXXX
0737 - 22XXXX

Moa Gustafsson
moagustafsson@XXXX
0768 - 39XXXX

B. Interviewee specification

Interview Specification					
Interviewees	**Company**	**Position**	**Experience**	**Interview method**	**Date**
I1	Coop	Head of Quality	Worked at Coop since 2014	Face-to-face	2017-03-29
I2	Coop	Quality Manager	Worked at Coop since 1974	Face-to-face	2017-03-28
I3	Coop	Purchase and Category Developer	Worked at Coop since 1982	Telephone	2017-04-06
I4	Coop	Supply Chain Manager	Worked at Coop since 1987	Face-to-face	2017-03-28
I5	Coop	Sustainability Strategist	Worked at Coop since 2015	Face-to-face	2017-03-29
I6	Coop	Store Quality Manager (HQ)	Worked at Coop since 2010	Face-to-face	2017-03-28
I7	Scan	VP Quality and CR	Worked at Scan since 1987	Skype call	2017-03-22
I8	Coop	Quality and Master Planning Manager, fresh goods	Worked at Coop since 2013	Face-to-face	2017-03-22
I9	Coop	Transport Planning Manager	Worked at Coop since 2006	Telephone	2017-04-05
I10	Postnord	Production Manager	Worked at Postnord since 2001	Telephone	2017-04-03
I11	Coop	Regional Store Quality Manager	Worked at Coop since 2016	Face-to-face	2017-03-30
I12	Coop	Anonymous	----	Telephone	2017-04-04
I13	Coop	Store Manager	Worked at Coop since 1988	Face-to-face	2017-03-27
I14	Supplier of TTI A	CEO	Worked at company since 2014	Face-to-face	2017-03-27
I15	Supplier of TTI B	CEO & Country Manager	Worked at company since 2014 & 2016	Skype call	2017-03-23

C. Interview guide – Coop supply chain

Dear XX,

First of all we will start by introducing our project to give You an understanding of what we are examining here at Coop. As we presented to You in our email, we are two students attending a master programme in logistics and transport management at the School of Business, Economics and Law at the University of Gothenburg. Currently, we are in the process of writing our master thesis in collaboration with Coop where we are investigating a potential implementation of time-temperature indicators in their cold chain, primarily focusing on fresh meat products. More specifically, fresh meat products produced under Coop's own brands. Consequently, we are examining possible benefits and risks with an implementation, as well as how these innovations would be implemented.

Initially, we would like to start by asking You some questions regarding your position at Coop, followed by main questions related to temperature indicators, food quality and safety, sustainability, as well as traceability aspects in the meat supply chain. We will finalise the interview with some future thoughts and practical questions. Does that sound good to You?

Before we start, would it be ok for You if we record the interview?

Opening questions

1. Tell us about Your position at Coop.

2. What is Your previous experience and how long have You been working at the company?

3. Tell us about Your division and its main responsibilities.

Main questions

4. What is Your division's definition of food quality?

5. How does Your division work to guarantee food quality?
    a) What are the benefits and risks associated with guarantee food quality today?

6. What is your perception of the amount of quality and temperature breakage along Your part of the chain?

7. How does Your division work to enhance sustainability and minimise food wastage?

8. What is your perception of the amount of food wastage within Your part of the chain?
    a) How large share of this is unnecessary wastage?
    b) What is the primary cause of this wastage?

9. What is Your division's definition of traceability and how do You work to ensure traceability of food products along the chain?

10. Tell us about Your previous experience regarding time-temperature indicators.

For this project we are primarily emphasising two different technologies: indicators measuring whether a temperature breakage has occurred in the cold chain, and time-temperature indicators integrating time and temperature to simulate microbiological growth in order to visualise the remaining shelf life of the product.

11. What is Your general opinion regarding this type of technology?
    a) What benefits and risks do You consider are associated with these innovations?

12. From Your perspective, what are the benefits and risks associated with each of the two technologies?

13. How would an implementation of these types of technologies affect Your part of the supply chain?

14. What is Your view regarding an implementation from a sustainability perspective, specifically its potential effect on food wastage?

15. What is Your opinion regarding the long-term effect associated with an implementation?

16. Based on Your experience and knowledge, to what extent should an implementation be applied in the cold chain?

17. To what extent would an implementation affect the consumers' perceptions of food quality?

Closing questions

18. What is Your perception regarding the future of time-temperature indicators?

19. Do You have any additional information to add?

20. Do You prefer to be anonymous or do we have Your permission to publish Your title in the report?

21. Do we have Your permission to contact you for further clarifications or questions after this interview?

22. Do You prefer to review and confirm our compilations of this interview before it is published in the report? Since the information will be translated into English, we would like for You to confirm that our interpretations have been made correctly.

D. Interview guide – Suppliers of indicators

Dear XX,

First of all we will start by introducing our project to give You an understanding of what we are examining here at Coop. As we presented to You in our email, we are two students attending a master programme in logistics and transport management at the School of Business, Economics and Law at the University of Gothenburg. Currently, we are in the process of writing our master thesis in collaboration with Coop where we are investigating a potential implementation of time-temperature indicators in their cold chain, primarily focusing on fresh meat products. More specifically, fresh meat products produced under Coop's own brands. Consequently, we are examining possible benefits and risks with an implementation, as well as how these innovations would be implemented.

Initially, we would like to start by asking You some questions regarding Your position at the company, followed by main questions related to temperature indicators and Your technology, the benefits for implementation, and how the technology could be implemented in the meat supply chain. We will finalise the interview with some future thoughts and practical questions. Does that sound good to You?

Before we start, would it be ok for You if we record the interview?

Opening questions

1. Tell us about Your position.

2. What is Your previous experience and how long have You been working at the company?

3. Tell us about Your company.

Main questions

4. Please explain the idea and technology of Your innovation.

5. To what actors is Your innovation targeted?

6. Please elaborate regarding the overall benefits and challenges associated with this technology.

7. What are the associated benefits and risks associated with the technology from the perspectives of: producers, distributors, stores, customers?

8. To what extent should Your innovation be implemented?

9. What is Your opinion regarding a potential implementation that includes the consumer stage of the supply chain?

10. How accurate is Your technology and innovation?

11. What can Your innovation offer the retailer?

12. What are your opinions regarding variations in quality of the product at point of packaging? To what extent is this taken into consideration when determining remaining shelf life?

13. What response have You received from previous implementations?
    a) From retailers?
    b) From consumers?

14. How have the consumers changed their purchasing behaviour after the implementation of Your innovation?
    a) Do consumers still choose the products with the longest remaining shelf life?

Closing questions

16. What is Your perception regarding potential further developments of Your innovation?

17. Do You have any additional information to add?

18. Do You prefer to be anonymous or do we have Your permission to publish Your title in the report?

19. Do we have Your permission to contact you for further clarifications or questions after this interview?

20. Do You prefer to review and confirm our compilations of this interview before it is published in the report? Since the information will be translated into English, we would like for You to confirm that our interpretations have been made correctly.

E. Interview guide – Focus group

All questions were asked in relation to fresh meat products.

1. What are Your perceptions when choosing meat product in store?

2. What does food quality mean to You?
    a) What does food safety mean to You?

3. What are Your thoughts regarding freshness of products and the printed 'best-before' date?

4. Do You trust the handling of food from farm to store? Why/Why not?

5. What are Your thoughts regarding the amount of information provided by retailers regarding the quality and handling of meat products?

6. How do You reflect upon Your handling of food from store to home?
    a) How do You reflect upon Your handling of food when at home?

7. What is Your thoughts about food wastage?

8. If there was a solution that could show whether or not the temperature has been correct the entire product's life time, what would Your thoughts be about that?

9. If there was a solution that could *also* show the number of remaining days of a product's life time, what would Your thoughts be about that?

The moderators tell the focus group about the two different indicators' function and show samples.

10. If You had to choose between one of them, which one would You prefer and why?

11. What are Your opinions about an indicator designed to be used by consumers?

12. How would an indicator affect Your behavior?
    a) Handling?
    b) Food wastage?

13. How much extra would You be willing to pay for an indicator?

14. How would TTIs affect Your perception about the brand using these indicators on their products?

15. What is Your general opinion about Coop?

a) How would an indicator on Coop's own meat products affect Your opinion about Coop?

F. Examples of time-temperature indicators

F.1 Indicator measuring whether a temperature break has occurred

Intact cold chain

Broken cold chain

F.2 Indicator integrating time and temperature to simulate remaining shelf life

G. Coding scheme

The following table presents the result from the coding of the conducted interviews and focus group. The initial parts of the themes 'Quality' and 'Future' are consistent with the overall emphasis of the theme and are therefore not further refined or categorised.

Themes	Quality	Efficiency
Categories		*Time pressure*
	Intact cold chain	Time a vital factor
	Food safety	Short lead times due to perishable products
	Handling of products	Time consuming controls
	Trust	Focus on shelf-life
	Consumers want maximum freshness	*Cost*
	Best-before date not an accurate indication of shelf-life	Common denominator through all stages
	Bad handling	Price sensitive consumers
	High on the agenda	Negative consumer perception to price reductions
	Quality processes	Cost focus influence wastage at consumer stage
	Standardised way of working	Consumer less price sensitive for more expensive products and online retail
	Temperature monitoring	*Food wastage*
	General policy being locally adjusted	General issue in supply chain
	Measure and Follow-up on quality processes	Consumer largest contributor
	Quality requirements on actors	Overproduction
	Traceability	Cause of unnecessary expenditure
	Self-monitoring system	Societal system encourages and demands wastage
	Quality risks	Lack of knowledge among consumers
	Temperature spot-checks	Misleading best-before dates
	Up to all actors to take responsibility	Types of food wasted
	Human errors	Limited reflection by consumers concerning food handling
	Lack of temperature history	
	High margin of error of temperature measurements	

Implementation		Communication	Future
Benefits		*Internal understanding*	
Competitive advantage	Inventory system	Understanding purpose with implementation	Increasing consumer awareness
Efficient control	Improved quality processes at store	Training	Upcoming trend
Dynamic best-before date	Improved quality of products	Disinterest from market	Alternative usage for indicators
Increased awareness	Shelf-life precision	Handling requires skills	More digital
Right in time	Improved handling at home	*Educating consumers*	
Increased food safety	Increased retailer trust	Importance of communication and education of consumers	
Minimise human error	Decreased food wastage	Increasing quality awareness	
Transparency	Visual shelf-life	Limited information provided to consumers	
Goodwill		Lack of knowledge	
Risks		Unawareness of food quality and handling	
Limited traceability	No effect on initial meat quality	Reduce uncertainty	
Novel technology	Price increase	Tool to initiate reflection among consumers	
Technological limitations	Uncertainty	Need for change in consumer behaviour	
Resource consuming	Increased food wastage	*Marketing management*	
Not useful for all actors	Not main purchasing criteria	Clear and simple communication	
Too reliant on technology	Decreased trust if insufficient cold chain	Challenge to reach consumers	
Economic loss due to less production		Avoid counterproductive	
Application of TTIs		The more the merrier: not always true in terms of info	
Consumer benefits	Indicate intact cold chain	Success of implementation requires informed consumers	
Decreased food wastage	Requires extensive testing and follow-up	Transparency	
Increased knowledge of handling	Level of implementation	Pedagogical	