Traceability in charitable food redistribution system – ensuring food safety and quality in a cold chain

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STADSMISSION

Traceability in charitable food redistribution system

Ensuring food safety and quality in a cold chain

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Abstract

Food waste, within the wider phenomenon of resource waste, has become a global issue due to its direct impact on climate change. Food redistribution via food banks is highlighted as a waste reduction strategy because it not only tackles the environmental impact from food production, but also provides food security to vulnerable people by redistributing the discarded food from food industries to social organizations. This emerging actor in the food chain deals with food in susceptible states and lies at the far end of the chain. To ensure that food safety and security is not compromised, good traceability in the whole food chain is essential to guarantee the quality of food supplied to those in need.

This study investigated Stockholm's Stadsmission food bank on its traceability practices and emphasized the challenges of food redistribution with regards to safety and quality. The aim was to provide the food bank with ideas for improvement. The study showed that the traceability practices at the food bank were sufficient to guarantee food safety for the current operating conditions, though potential for systematic errors was still detected. While the Swedish chicken food industry displayed a supply chain with good temperature control, the main challenge in redistribution was a lack of temperature control at all receiving and dispatching points. The thesis concludes that the food bank should implement more robust traceability systems in preparation for the anticipated growth of the food redistribution industry.

Keywords: Traceability, Cold chain, Food bank, Chicken food chain, and Temperature monitoring

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Lund, May 2017

Natthida Ananprakrit and Maria Eugenia Esbjörnsson

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1 Introduction

This section provides an idea and understanding of the background of this thesis work, giving a brief introduction to food waste situation and the attempt to reduce the waste through redistribution via food banks. It is followed by a problem description and the aim of the study, together with delimitations and focus. This chapter ends with the outline of the report.

1.1 Background

The Food and Agricultural Organization of the United Nations (FAO) states that the amount of food waste worldwide reaches 1.3 billion tons which is equivalent to a third of all food produced globally, while almost 800 million people are hungry (FAO, 2017). Meanwhile the European Commission (EC) (2017a, 2017c) reports a food waste between 88 and 100 million tons of food waste annually in Europe, carrying an associated cost of 143 billion euros in estimation. In Sweden, it has been quantified at 1.1 million tons in 2010 and 1.2 million tons in 2012, of which 62% is produced in households (Naturvårdsverket, 2014).

This loss occurs along the food supply chain. In industrialized countries, this phenomenon is exacerbated at retailer and consumer levels due to many factors, for instance, misunderstanding between “Best Before Date” (BBD) and “Used by”, surplus of seasoning product or inadequate storage and transport along the food chain, among others.

Besides all these issues, it has been identified that the lack of awareness on the part of many actors creates a sheer scale of problem. However, it also indicates a great deal of opportunities and benefits if the mindset of reducing food waste is awaken (European Commission, 2017b). Awareness of the situation is crucial otherwise if there are no immediate action taken, the food waste may rise to 126 million tonnes by 2020 (Michalopoulos, 2017).

In response to this, in November 2011 the agriculture committee of the European Parliament approved a resolution that requests the European Commission to take measures aiming at reducing waste by 50 percent before 2025 (Koester, 2014). Later, in September 2015, the FAO defined the 17 Sustainable Development Goals to tackle contemporary global challenges for humanity and the world over the next

15 years. (FAO, 2017; United Nations [UN], 2016). Goal 12 "*Ensure sustainable consumption and production patterns*" is deployed in several targets, the third of which reflects the awareness of the importance of waste reduction: *"12.3 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses"* (UN, 2016, p. 28).

Food redistribution through food banks is one of the attempts to reduce food waste because it deals with surplus from food businesses. It contributes to reduce the environmental impact associated with food production and consumption, as well as to provide food to those in need (Gram-Hanssen et al., 2016).

In Sweden, three situations are given to redistribute food by operating food banks. One of them is the amount of food waste which exceeds one million tons yearly. A second situation is the increase of people in need. For example, approximately 4000 beggars - primarily from Romania and Bulgaria - arrived in the Spring of 2014, which means a double increase of EU migrants compared with a previous year (Olsson, 2015). Last is the interest of producers, distributors and retailers to mitigate the environmental impact and to support the more vulnerable people (Fédération Européene des Banques Alimentaires [FEBA] et al., 2016; Michalopoulos, 2016).

Thus, Stockholms Stadsmission opened a central food bank in May 2016. The food bank acts as a "back-line" organization since it is an intermediary between the whole food supply chain and the "front-line" organization which has a direct contact with the people in need. (FEBA et al., 2016).

1.2 Defining the problem

Food banks generally deal with food that is close to its BBD as it is one of the alternatives to prevent almost expired food from being wasted by redistributing them to socially disadvantaged people. The vulnerability of the foods becomes heightened when compared to the fresh foods with its shorter remaining life. Consequently, solid control measure is required to ensure the safety and quality of the foods. A good traceability system; where all stages of production, processing, and distribution of the food can be tracked (European Commission, 2007); plays an important role in ascertaining food quality by understanding what is happening to the food along the whole chain, e.g. handling process, and being able to trace back the origin of the food if any incidents occur.

Insufficiency in implementing traceability and control mechanism would potentially devastate the whole food bank idea if any spoiled food is unintentionally served and causes illness in consumers from food poisoning. Health issue raises a big concern as it will not only damage the reputation of the food bank but also directly affect the names of the food donors, which could be food manufacturers or wholesalers or others, who hold criticality to their brand images to run their businesses. Inability to ensure the safety and quality of foods in redistribution system may refrain them from participating in donating programs, reducing main supporters to the food banks, which would eventually bring an end to redistribution activities.

Stockholms Stadsmission has recently established the first central food bank in the Swedish capital, with one central warehouse serving several social organizations. The number of donors participating is still very small. Accordingly, the food flow is uncomplicated and traceability can be managed manually for the time being. However, progressing forward with anticipation to manage the increasing amount of food, the need for a solid control mechanism and traceability system is undeniable. Not only to ensure the safety and quality of food, but also to sustain the food bank's concepts, activities, and growth in long term.

This thesis work is intended to answer the following questions.

Question 1: How does the food bank perform traceability in their redistribution chain? Is it sufficient to ensure food safety?

Question 2: What are the critical activities/ points that potentially affect food safety during cold chain in redistribution activity?

1.3 Aim of the study

The aim of the study is to analyze the traceability system and the cold chain management of the food bank, to identify critical points and challenges surfaced in redistribution activities, and to suggest control measures to ensure food safety and quality along the chain. Critical points can be defined as a point where the food is subjected to temperature condition higher than the recommended controlled temperature for the optimal quality.

1.4 Focus and Delimitations

The research is focused on the chicken food chain, as a representative study object to investigate the cold chain of the food bank. The field test is performed to collect realistic temperature condition on the chicken being delivered from one donor to the food bank, and to the social organizations. Two tests are conducted in March and May to observe data under varying climate conditions. The time of the research limits the possibility to carry out extensive tests under more extreme conditions where air temperature is higher (e.g. summer-time). The findings are thus built upon a moderate control factor.

The interviews with different actors in the chicken chain have been performed to evaluate potential risks in the cold chain. Data is collected from one to two companies at each actor level from farms, slaughterhouses, processing plants, distribution centers, retailers, and logistic service providers.

In studying the Swedish supply chain, the inability to understand the local language or Swedish becomes another barrier to access a variety of Swedish information related to the topic.

1.5 Outline of the report

This report consists of seven chapters. A brief description of each chapter can be found below.

Chapter 1: Introduction

The first chapter explains the background of the study, giving a brief introduction to food waste situation and the attempt to reduce the waste through redistribution via food banks. Then, the purpose and the aim of the study are presented, together with delimitations and focus. This chapter ends with the outline of the report.

Chapter 2: Frame of reference

The second chapter reviews relevant literatures and theories to establish a frame of reference and to provide fundamental knowledge essential to execute the research. It starts with a brief description of the food bank concepts, as well as the law and regulation requirement imposed on this kind of organization. Then the frameworks on the traceability system and the cold chain management are presented in order to provide ideas on how to evaluate the food bank. It ends with a short guideline on chicken handling to facilitate assessment of the chicken food chain.

Chapter 3: Methodology and Method

This chapter discusses research methodology, explains how the research is conducted, e.g. data collection procedures, and examines its overall credibility.

Chapter 4: Results

In this chapter, the food bank's supply chain is firstly described, followed by its practices regarding the traceability and the quality management for the cold chain. Then the realistic temperature data collected from the field tests are presented. The last section of chapter focuses on the upstream part of the chicken chain, where interview results from different actors, farms to retailers, are described.

Chapter 5: Discussion

This chapter shows the analysis of the obtained results, in connection with theoretical foundation. The discussion is split into two parts: first the food bank's redistribution activity involving the donor and the social organizations, and then the chicken food chain in Sweden.

Chapter 6: Conclusions

The chapter summarizes the study by addressing the research questions and developing suggestions for the food bank. Contribution of the thesis work is also presented.

Chapter 7: Suggestions for further studies

The last chapter suggests areas for further studies.

2 Frame of reference

This section reviews literatures and provides a brief description related to the area of the study. A number of relevant theories and previous studies are presented to establish a knowledge foundation for the research execution.

2.1 Food bank and food redistribution concepts

The concept of food banks was originated from the wish to help low income people to have edible food, improving the quality of life (FEBA, 2017; Hanssen et al., 2015; Persson, 2016). As non-profit organizations, the food banks bring donated food to the poor (FEBA, 2017; Kim, 2015). Hanssen et al. (2015, p.9) limits *"the concept of food banks to specific organizations that have been set up to function as open redistribution centers and where several stakeholders collaborate in establishment and operation"*. Food banks thus act as an intermediary between food sectors and social organizations (Hanssen et al., 2015), performing the tasks of collecting, transporting, sorting, storing, and redistributing food according to regulated standards of food safety and security (FEBA, 2017).

Food redistribution, on the other perspective, is viewed as a concept of food waste prevention and reduction, especially in Nordic countries. Adding another role of safeguarding food security for people in needs, food banks serve as one of the effective measures to reduce food waste. They collect the food, that would otherwise be wasted by food companies, and redistribute them to charitable organizations that would feed them to the socially disadvantaged people. (Hanssen et al., 2015; FEBA, 2017; Persson, 2016) The benefit extends far beyond the receivers appeasing their hunger. By having the surplus food collected by food banks, the food businesses would be able to cut down the expense of treating food waste (Hanssen et al., 2015), subsequently reducing negative environmental impact generated during industrial processes.

2.2 Law and legislation requirements

The Swedish national food legislation is, to a large extent, harmonized with the European Union's (EU) food regulation since Sweden is a member of the EU (Wideback, 2012). An EU regulation applies directly and has precedence over a Swedish national law. The general food law in force is the Regulation (EC) No. 178/2002 which aims to *"provide a framework to ensure a coherent approach in the development of food legislation across the EU"* (Gheoldus, Jan & O'Connor, 2014, p.3) and address concepts such as risk analysis, precautionary principle, food safety, accountability and traceability (Lindholm, 2009). The law applies to all stages of production, processing and distribution of slaughter and/or harvest from transport to marketing and sales, as well as food business operators (e.g. shop and restaurants), in a similar way that the European constitution applies to them (Regulation, 2002; Lindholm, 2009).

Nevertheless, Sweden has a complementing law -in its food law- in addition to the laws and regulations from the EU (Persson, 2016; Sveriges Riksdagen, 2006). Standards are utilised such as Swedish KRAV-Label which is promoted by KRAV association who develops a quality system for organic food; or the use of Swedish Sigill brand which follows the IP-Food standard owned by Sigill Quality System for food safety, product and process quality of food producers (Sigill, 2014; Wideback, 2012).

Currently there are no specific regulations for food banks in Sweden, and the food banks are considered by the EU as food business operators (Persson, 2016), implying that any regulatory compliance demanded on normal industry players has to be strictly exercised by the food bank. Additional guidelines or legal requirements on food safety may influence the food bank´s practices, for instance, the guideline for the donation of food past its BBD written by the FEBA, is a tool available for those food businesses that want to engage with the FEBA members (FEBA et al., 2016).

Additionally, within EU, there is no homogeneous policy for food donation as Gheoldus et al. (2014, p.2) affirm it *"There is no common EU policy on food donation; policy frameworks in Member States (MS) vary, enabling donation to greater or lesser degrees."*

2.3 Traceability system

The traceability concepts

There have been many cases where the food industry has had to deal with problems. The emergence of the Bovine Spongiform Encephalopathy (BSE) or "mad cows" disease in United Kingdom in the late 90´s, was the first incident that awakened the need to count with proper documentation and to perform practices of traceability in cattle and in the food industry. (Bendaoud, Leconte & Yannou, 2007; Grujić et al., 2012; Wales, Harvey & Warde, 2006; Wang, 2013)

Traceability is a widely used term for many authors according to their research perspectives. The concept has evolved and its importance in the industry has been increasing. In the Codex Alimentarius traceability is defined as *"the ability to follow the movement of a food through specified stage(s) of production, processing and distribution"* (Food and Agriculture Organization/World Health Organization [FAO/WHO], 1997, p. 1). In European legislation, the term traceability within the food industry is broader and is defined in the Regulation (EC) No 178/2002 as *"the ability to trace and follow 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"* (Regulation, 2002, p. 8).

Tracking and tracing are different concepts that are fundamental part of the traceability. Tracking is the ability to follow the downstream path along the supply chain, from the origin point to the product consumption. It is crucial to have implemented the tracking in order to recall products efficiently. Tracing, on the other hand, is the ability to follow the upstream in order to identify the origin and characteristics of a particular product or of a group of products in the supply chain (Bechini, Cimino, Lazzerini, Marcelloni & Tomasi, 2005). Figure 2.1 shows the tracking and tracing flows.

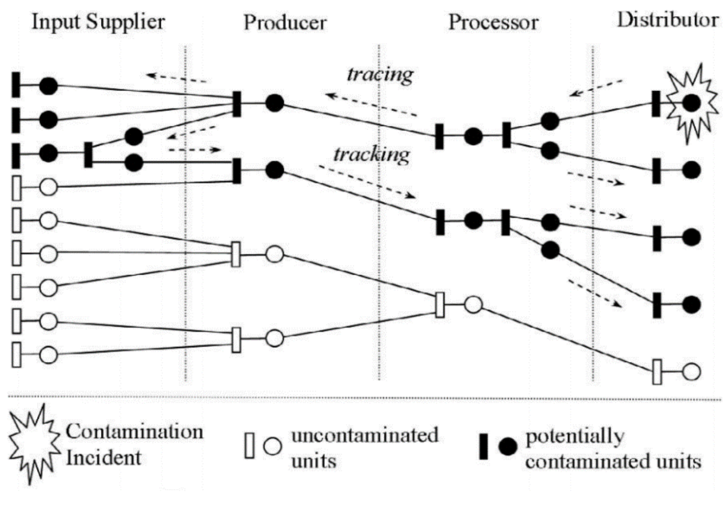


Figure 2.1 Scenario of traceability in a supply chain (Bechini et al., 2005)

The identity of the product is crucial to be able to perform the traceability of a product within a company. The batch is the most common way to group a certain quantity of same product, which is identified by using some kind of labeling with a batch number, that is unique and unrepeatable. This number is the tool to trace during the processing and to connect it either upstream with the raw material, or downstream with the finished product. (Stadig et al., 2002.)

Bechini, Cimino, Lazzerini, Marcelloni and Tomasi (2005) describe the scenario of a contamination event detected at the end of a simple supply chain composed by suppliers, producers, processors and distributors as shown in Figure 2.1. The circle represents a traceability lot which is the unit of the food product in similar condition either processed or packed, or a mass of products that share the same characteristics, similar to the batch concept mentioned previously and stated by the international non-profit organization GS1 (2007) as synonymous. The rectangle denotes an activity for instance production, distribution or sale. Each activity may have N number of lots as input and M lots as output. The lots and the activities are linked by a line that creates the route of the lots.

According to the GS1 (2007, p.7), internal traceability occurs *"when a Traceability Partner receives one or several instances of traceable items as inputs that are subjected to internal processes, before one or more instances of traceable items are output"*. The internal processes must consist of at least one of the four sub-processes such as movement, transformation, storage and destruction. External traceability happens *"when a traceable item is physically handed over from one Traceability Partner to another"*. Each Traceability Partner is responsible for performing the *"one step up, one step down"* principle, which is the ability to trace a product back to its direct source and the ability to identify the direct recipient of the specific traceable product (GS1, 2007, p.8).

Figure 2.2 displays clearly the internal and external traceability concepts that each actor must perform individually in order to achieve successful traceability management across the supply chain. Figure 2.2 also shows the information flow that moves backward and forward along the supply chain, which highlights the importance of sharing communication in a cross functional environment.

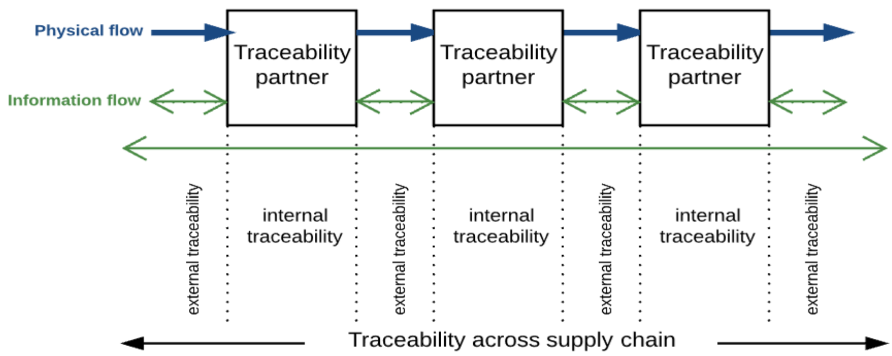


Figure 2.2 Internal, external and supply chain traceability (GS1, 2007)

The traceability system (TS) and different frameworks

Bendaoud, Leconte and Yannou (2007, p. 2) highlight the importance within the companies to establish means that enable them to trace and track their products, as the regulation states, by the implementation of a traceability system (TS). These authors thus define TS as a *"system structured in such a way that it allows to totally or partially reconstruct the lifecycle of a given set of physical products"*.

A better understanding of the TS structure is described by different authors. Moe (1998) describes, as can be seen in Figure 2.3, a fundamental structure that traces both the product and the activities (core entities). Both of them have essential descriptors to be traced such as type of product, type of activity, amount of product, time and/or duration of the activity. The information related to them must be collected or measured and stored. Some specific examples are shown under the sub-descriptors column in the mentioned figure in order to describe the extent of the TS which may include quality attributes and/or environmental factors. (Moe, 1998)

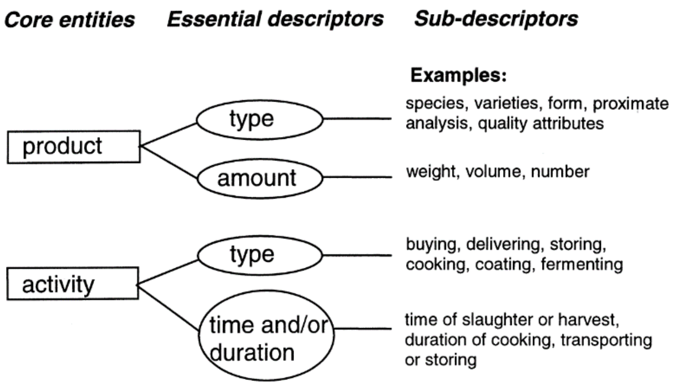


Figure 2.3 Fundamental structure of a traceability system (Moe, 1998)

The four pillars of the TS framework proposed by Regattieri, Gamberi and Manzini (2007), as seen in Figure A.1 in Appendix A, coincides with Moe´s point of view regarding to the product identification, data to trace and product routing or processes. However, the four pillars are broader since they include tools to achieve the traceability, such as alphanumerical code, bar code or radio frequency identification (RFID), for the proper functioning of a TS.

2.4 Cold chain management

A cold chain describes the process that "*brings the temperature-sensitive products from the factory to the consumer"* under an uninterrupted temperature-controlled environment (Carullo, Corbellini, Parvis, & Vallan, 2009) to ensure product quality and safety is maintained (Ma & Guan, 2009). As the name implies, temperature is regarded as "*the most important environmental factor"* in the cold chain (Bruckner, Albrecht, Petersen, & Kreyenschmidt, 2012). "*The rise in temperature of just a few degrees can cause microbial growth leading to the great decrease of quality, spoilage of foods and the increase of the risk of food poisoning"* (Aung & Chang, 2014), as well as generating economic loss (Raab, Petersen & Kreyenschmidt, 2011).

As the quality of most food products is greatly affected by temperature and time, it demands stringent temperature control and time management (Montanari, 2008). Regulation (EC) No 852/2004, which is the "Regulation on the hygiene of foodstuff", clearly states that the cold chain is not to be interrupted, but "*limited periods outside temperature control are permitted"*. This highlights the need for chain traceability to ensure the controlled condition is maintained (Raab et al., 2008), as a failure to control temperature at any step will negatively affect the final quality of the product.

Food chains generally consist of diverse organizations, or actors, with different systems and processes. The ability to maintain the controlled condition in a single organization may not raise many concerns, however, managing the links or transfer points between different organizations has been found to be a major source of incorrect temperature conditions (Raab et al., 2011; Olsson, 2004). During the transfer process, many papers have identified *"the product cooling prior to palletizing or loading at the producer, waiting times at dispatch and loading points, temperature abuse during transport caused by excessive door opening times and inappropriate handling and storage of the goods at the retailers"* (Raab et al., 2011, p.1268) to be critical temperature points within the meat supply chain (Olsson, 2004; Montanari, 2008; Raab et al., 2008). Refer to Table A.1 in Appendix A for all critical points identified by Olsson (2004) in food supply chain.

To identify and control these vulnerable points in the cold chain, efficient temperature monitoring becomes a task that must be achieved by all actors involved in the supply chain, from producers, to processors, distributors, retailers, and consumers (Raab et al., 2011; Bruckner et al., 2012).

Temperature monitoring in cold chains

Many studies have been conducted regarding temperature monitoring in food supply chains. Carullo, Corbellini, Parvis, Reyneri and Vallan (2009) and Raab et al. (2008) have found that environmental temperature does not always provide a meaningful indicator for food condition. Due to thermal properties of the products, which is associated with their nature and packaging, Raab et al. (2008) found that the product temperature was almost unchanged, even though it was subjected to temperature fluctuation during the unloading process. Moureh and Derens (2000) also found that "the environmental temperature often differed from the product temperature" during storage and transport (Raab et al., 2008). However, the longer the product spends in the undesirable temperature condition, the faster the quality loss (Aung & Chang, 2014). Therefore, it is still necessary to monitor temperature, as temperature is the most prevalent factor affecting product quality. Furthermore, James, S., James, C., and Evans (2006) suggests to combine temperature monitoring solutions with heat transfer models.

However, various products exhibit different thermal sensitivities e.g. poultry fillets are easily affected by rise in temperature than beef fillets. Analyzing displayed product temperatures consequently requires careful consideration of the thermal properties of each individual product (Raab et al., 2008; Raab et al., 2011).

Generic model to assess the cold chain

Raab et al. (2008) developed a generic model to predict remaining shelf life in different cold supply chains, as shown in Figure 2.4.

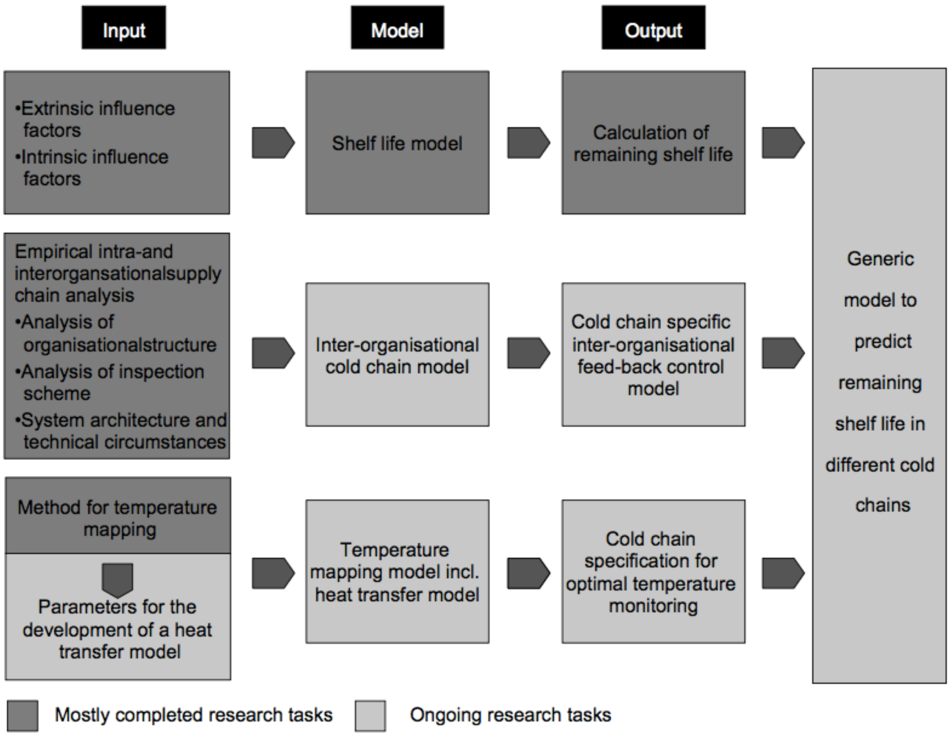


Figure 2.4 A generic model to predict remaining shelf life in different cold chains (Raab et al., 2008)

The model is divided into three main areas: shelf life model, inter-organization cold chain model, and temperature mapping model with heat transfer. When assessing any cold chains in term of organizational aspect, Raab et al. (2008) considers the following three elements:

- Analysis of organizational structure provides the idea of the chain characteristic, illustrating product flow and halt at each step, for e.g. how long does the food stay at distribution locations, length of transportation routes, which would outline the constraints/challenges imposed on the food in that specific chain.
- Analysis of inspection scheme investigates works routines and procedures regarding quality inspection check at transferring points as well as during the process. This would include the cooling technology used.
- System architecture and technical circumstances probes on how to collect, retain, and transfer quality data; for example, temperature.

This part of the model provides guidance on how to evaluate the cold chain from the organizational point of view in a well structured manner. To meet the objective of predicting remaining shelf life in the cold chain, Raab et al. (2008) combines this organizational assessment to the temperature mapping and the shelf life model in their framework.

The framework proposed by Raab et al. (2008) covered both traditional supply chain management perspective, focusing on product and information flows, and temperature assessment part. Regardless of its final applicability, the model lays a good foundation of how to assess the cold chain.

2.5 Chicken meat handling

Improper handling or contamination in food preparation is the cause of most foodborne illness outbreaks in humans (United States Department of Agriculture [USDA], 2014). Among the most frequently reported foodborne diseases worldwide are the salmonellosis and campylobacteriosis caused by different species of the bacteria *Salmonella* and *Campylobacter* respectively (FAO and WHO, 2009).

In the EU, the most frequently reported illness is the campylobacteriosis (i.e. over 190 000 human cases annually) whose symptoms are diarrhea (frequently bloody), abdominal pain, fever, headache, nausea, and/or vomiting due to the presence of the bacteria in fresh meat from pigs, lambs, cattle and poultry (European Food Safety Authority [EFSA], 2014; WHO, 2016). Lawley (2013) states that *Campylobacter* in poultry meat is greater than in other fresh meats. In addition, fresh poultry is more frequently and more heavily contaminated than frozen poultry. *Campylobacter* species multiply at low levels of oxygen (e.g. 5% found in the digestive tract of the chickens) and at relatively high temperatures such as 30-45°C with an optimum temperature of 42°C.

In the Swedish poultry industry, *Salmonella* in chicken is controlled efficiently since the governmental regulation took place in 1961 (Svensk Fågeln, 2010).

Campylobacter has shown low presence of 11.6% positive in 2015 (Svensk Fågeln, 2016) which is one of the lowest levels among the European countries.

In order to prevent illnesses, the actors in the food chain and the consumers should put into practice sanitary food handling and proper cooking and refrigeration measures. The Food Safety and Inspection Service (FSIS) in the United States recommends to store the fresh whole chicken and chicken parts as shown in Table 2.1 (USDA, 2014).

Table 2.1 Home storage of chicken (USDA, 2014)

Product	**Refrigerator** 40°F (4.4°C) or below	**Freezer** 0°F (-17.8°C) or below
Fresh chicken, whole	1 to 2 days	1 year
Fresh chicken, parts	1 to 2 days	9 months

The guidelines of sanitary food handling practices describe several methods of thawing chicken (USDA, 2014; FAO, WHO and Pan American Health Organization [PAHO], 2016):

- *In refrigeration:* frozen chicken may take around 1-2 days or longer to thaw. Once that chicken thaws, it can stay in the refrigerator 1-2 more days until it is cooked. If it is not used, it can be safely refrozen without cooking.
- *In cold water:* frozen chicken must be packaged in a leak-proof bag, submerged in cold water, and the water should be changed every 30 minutes to ensure that it is always cold. A whole chicken that weighs between 1.5-2 kg may take 2-3 hours to thaw and a boneless chicken that weighs 0.5 kg, may take 1 hour or less. The chicken must be cook immediately after thawing.
- *In the microwave:* some areas of the chicken may become warm and begin to cook during thawing, which means that the bacteria have not been destroyed. The chicken must be cook immediately after thawing.
- *As part of the cooking process:* this process applies only for small portion of chicken, and is such that the chicken thaws once the correct temperature has been reached. The cooking time may be about 50% longer compared to cooking an already thawed chicken portion.

In order to destroy the *Campylobacter* in chicken, adequate cooking temperatures and times for chicken are described in Table 2.2 (Ministry of Health of New Zealand, 2001).

Table 2.2 Adequate cooking guidelines (Adapted from Ministry of Health of New Zealand, 2001)

Cook meats to:	Internal temperature reached	Time
Poultry, breast	77°C	15 sec
Poultry, whole	82°C	15 sec
Reheat cooked food to	74°C	Instantaneous

3 Methodology and method

This section describes research approach selected for the study, the design of the case, and data collection methods. This chapter ends with the discussion on the credibility of the paper.

3.1 Research approach

This research takes the form of a qualitative case study of redistributive food chain practices at Stockholms Stadsmission´s food bank. The focus is directed at the traceability system of the cold chain, where temperature plays a critical role in maintaining food quality and is thus a key controlled parameter. Many former research papers have studied cold chain practices, but more in the upstream side of the chain: from farms until distribution points. Meanwhile, the studies that have focused on the process of food redistribution via food banks, another emerging actor, are very limited (Hanssen et al., 2014). To study an unexplored field, the case study methodology is appropriate (Yin, 2003), as it provides an in-depth understanding of a certain phenomenon and allows the questions of what, why, and how to be answered (Meridith, 1998).

The research process is structurally implemented by defining the research questions to clarify the focus of the study and demarcate research activities. A literature review is then conducted to provide the theoretical foundation for the proposed study and demonstrate the selected methods of data collection and analysis.

Golicic, Davis and McCarthy (2005) suggests that *"the choice of research approach (i.e., quantitative and/or qualitative) should depend on what the researcher wants to know as determined by the nature of the phenomenon and the type of research questions."* The qualitative approach is considered suitable for our specified research questions, and thus influences the way data is collected. Interviews, observations and field tests provide primary inputs for analysis in this paper. Interviews give direct access to the information in question (Björklund & Paulsson, 2014), but are subjectively biased depending on each respondent. Observations will therefore be incorporated to obtain data with more limited response bias. In addition, field tests would provide the significant advantage of having greater control over confounding variables (Björklund & Paulsson, 2014); for example, using superior equipment to monitor the study object in a well-defined environment would eliminate some undesirable uncertainties. However, these methods are undeniably time and resource intensive, which narrows the scope and limits the external validity of the study.

3.2 Case study design

This study investigates the traceability system and cold chain management performed by Stockholms Stadsmission's food bank ("Matbanken") in the light of ensuring food safety and quality in its charitable redistribution activity. Among its frequently donated food, one sensitive product is selected as the primary study object. Jens Jonsson, operations manager of Stockholms Stadsmission's food bank, indicates chicken to be a critical product with high volume and vulnerability to temperature changes. Thus, the chicken food chain in Swedish food industry has become the focal point.

Figure 3.1 illustrates the whole chicken chain with charitable redistribution at the end of the chain. The study examines the redistribution part, starting from the donor, in which only single donor is involved with the food bank for chicken donation at the moment, until the recipients or charitable organizations as many studies show that cold chain usually breaks at the consumer part (Raab et al., 2011; Olsson, 2004).

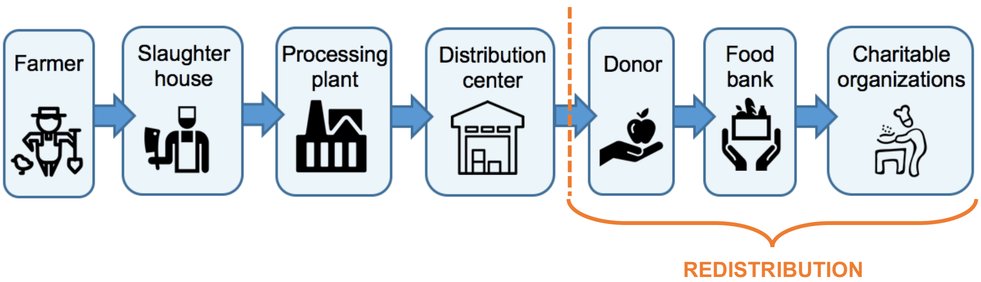


Figure 3.1 Chicken chain with redistribution activity

In order to obtain data during redistribution, besides from interviews and observations, field tests were conducted to collect temperature data from the donor cold storage to the food bank and to the recipients. The data was used to display realistic temperature conditions imposed on the donated food, which will reveal critical points with time-temperature abuse.

To gain a holistic view of the whole chicken chain, interviews with different actors in Swedish chicken industry are conducted to explore the practices in the upstream. 1-2 actors at each level from farms to retailers participated in the research.

3.3 Data collection

Inspired by the model suggested by Raab et al. (2007), this study has developed four main areas of data to be investigated: starting from organizational structures of the food bank chain, traceability practices, quality practices, and temperature mapping, as shown in Figure 3.2. Organizational structures which would lay the basic understanding of the food bank chain are primarily examined via interviews with the food bank. The chain characteristics would directly impact the planning for the field test. Secondly, the traceability practices and the quality practices are observed and interviews are undertaken with the food bank and its immediate actors (the donor and the recipients). Then, field tests are performed to map actual temperature data during redistribution activity, while observations of routine practices are made.

Figure 3.2 Four areas of data collection at the food bank and its chain

3.3.1 Organizational structures of the food bank chain

This part will explore the route the food travels and describe the *"product flow with regards to distribution ways, length, and sojourn time at different stops"* (Raab et al., 2007), characterizing the path the donated food has to go through. It also explains physical conditions at the food bank and its partner e.g. facility, equipments, resource, etc. in order to understand the working circumstance.

3.3.2 Traceability practices

This part will look for: what information the food bank uses to identify and trace products, what type of data they trace e.g. barcode, and what tools or technology they use to maintain this information. In addition, this part will investigate how they react when certain recall incidents happen, as the sole purpose of traceability is to ensure food safety by swiftly isolate and quarantine source of problem from spreading.

3.3.3 Quality practices

This part will look at quality inspection schemes and control mechanisms performed by the food bank, especially at transferring points as well as during the process, to ensure quality and temperature are maintained. The routine checklist, which could be sensory evaluation, use by date, BBD, package intact, product temperature, ambient temperature, etc. is evaluated.

3.3.4 Temperature mapping

Field tests were conducted to collect realistic temperature data during the redistribution chain, involving the food bank's donor, the food bank, and the recipients. The execution of the tests was carried out in two occasions, March 20-24 and May 2-5, 2017, to gain more extensive results from varying ambient conditions. Having chicken as the main study object as previously discussed before, multiple sensors were attached to the chicken packages which travelled from the donor to the recipients in the refrigerated truck operated by the food bank. This will reveal critical points where temperature exceeds the regulated controlled limit. The temperature monitoring continued until the moment before the chicken was cooked at charitable organizations.

In addition, to assess the environmental conditions where the chicken was being kept, the storage temperatures at the donor and at the food bank were monitored for the whole field test period.

During the field test, Bluetooth Low Energy (BLE) sensors supported by nRF51822 Nordic Semiconductor and Radio Frequency Identification (RFID) interface (RT0005, CAEN RFID) were used for measuring and logging time-temperature data in the chicken redistribution chain. The time-temperature data was continuously measured by the sensors, transmitting the data to nearby Sony Xperia mobile phones via Bluetooth every one minute. The mobile phones send the sensor data to a web server, where the information could be retrieved and exported to Excel afterward. Also, the sensor data could be exported directly from the mobile phones. All sensors were previously calibrated in a thermal incubator with calibration factors provided for each single sensor. These calibration factors have to be manually plugged in to the data retrieved from the devices.

3.4 Credibility in the research

It is crucial to ensure credibility or trustworthiness in research, which lies in the forms of validity, reliability and objectivity (Seale, 1999; Björklund & Paulsson, 2014). Validity refers to how well the selected research method answers what we intend to study. Reliability ensures the obtained result is accurate in a way that the research method yields compatible results if repeated. Objectivity recognizes diverse interpretation of the result which is not subjected to any individual bias.

This study incorporated field tests with interviews and observations to extract data. The tests were repeated multiple times in order to provide reliable results. The obtained data was presented empirically so that readers could reach independent conclusions, without the authors' influence. However, the authors' interpretation will be analyzed in the discussion.

4 Results

This chapter first shows the results from interviews, observations and field tests performed at the food bank with its immediate partner, the donor and the recipients. This part of the food chain is described in four areas as described in methodology: food bank´s chain, traceability practices, quality practices, and temperature data. Then the upstream of the chicken food chain is explained based on interview results with different actors in Sweden: from farms till retailers.

4.1 Organizational structures of the food bank chain

The food bank is a part of Stockholms Stadsmission´s social business units "Matcentralen" whose goals are to contribute to the reduction of food waste, to provide nutritious food to those in need and to integrate people in vulnerable situations into the workforce. It is based on three core enterprises: Food Mission, Food Bank and Food Work as shown in Figure B.1 in Appendix B. Food Mission provides reduced-price food to socially disadvantaged people. Food Bank collects and redistributes donated food to social organizations. Food Work is a future food processing project with the objective of adding value to the donated food e.g. catering, restaurant, etc.

The food bank currently redistributes approximately 1.5-2 tons of food to charitable organizations every week. In a day, only one delivery route is performed: beginning from the food bank's warehouse, arriving at the donor to collect donated food, directly delivering the food to social organizations, and returning back to the warehouse with surplus food, if any, as illustrated in Figure 4.1. The detailed routes covered during the week are shown in Table B.2 in Appendix B. The total travel distance varied day by day, ranging from 79 – 97 km for redistribution.

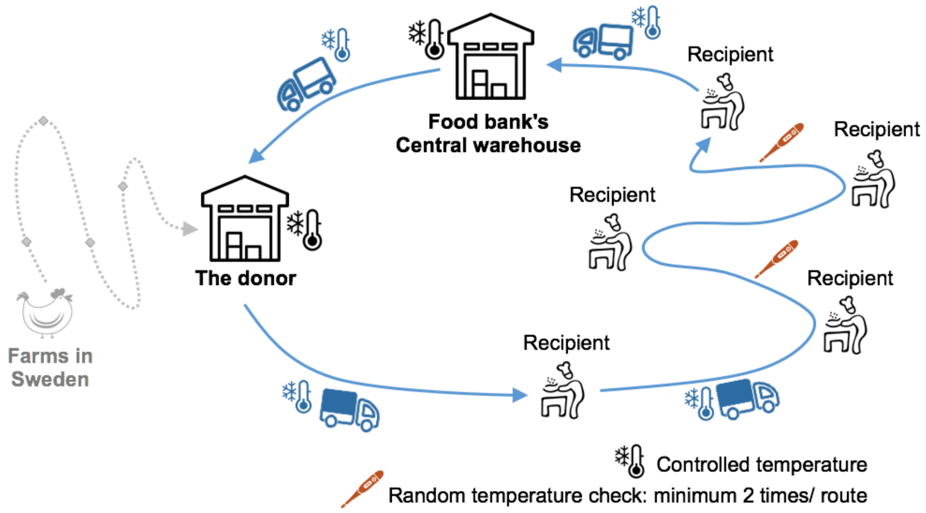


Figure 4.1 Food bank general route of redistribution.

Stockholms Stadsmission's food bank

The food bank has one refrigerated truck dedicated for all redistribution activity, transporting all types of food together in a single compartment (combined transport). The storages at the food bank´s warehouse provide better segregation with three different cold storages, as well as one freezer room, dedicated to different types of food: meat products, dairy products, and fruits and vegetables respectively, as shown in Figure 4.2. Each has a specific temperature controlled limit. The facilities are shared with other project of Stockholms Stadsmission, and only the specific zones are provided for the food bank, as illustrated in the Figure. All the food storages are located on the second floor, while the loading gate is located on the first floor connected by two elevators. The connecting area from the storages to the gate is not chilled.

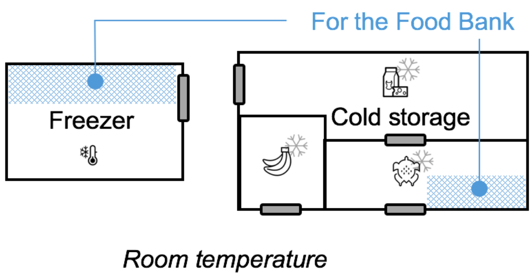


Figure 4.2 Freezer and cold storage at food bank´s central warehouse facility

All the food bank's physical activities in collecting and delivering food are mainly performed by one worker, the truck driver, which sometimes is accompanied with a trainee to the route. Every morning, the truck driver prepares the products to be transported from the food bank´s warehouse. The amount varies greatly depending on how much food is remained after delivery from the previous day. The leftover food can either be kept as frozen or fresh state depending on how close it is to BBD. The fresh food having at least 1 day before its BBD may be loaded to the truck if there is potential delivery. For the frozen product, only with confirmed orders from social organizations, it will be loaded in an insulated cabinet before transferring to the truck for transport.

Currently, the food bank leases a two-axle vehicle that carries maximum 630 kg which accounts with a tail lift, a cooling system and a plastic curtain to prevent the cold air leakage and/or the warmer air inlet during loading-unloading shunting. In the future, this vehicle will be changed to a new one with similar dimensions and capacity, but with a lateral opening door.

The Donor

The donor is an e-commerce store who sells products to customers, which can be both end consumers (business to consumer or B2C) or restaurants or retailers (business to business or B2B), via online orders. They receive all products from its distribution center (DC) located approximately 100 km away from Stockholm. All products, including perishable food, are stored inside their warehouse without being displayed on shelves for sale, unlike common supermarkets or retailers where products are displayed for consumers to touch and feel before purchasing. Inside the same cold storage, there is one specific zone where the food registered as waste is accumulated. If the food exceeds the time limit to sell, it is removed from picking areas to this waste corner. For the fresh chicken, the donor does not sell the chicken if it has less than 4 days prior to BBD. This chicken is then registered as waste. Since some of the waste food does not pass its BBD, they can be donated. The donor usually put a tag with "Matbanken" to signal the food bank that the food is good to take.

There were two donor facilities operating at the time of the study, since the donor was in a transition period of moving from the old warehouse to the new one. Both facilities are located in the southern part of Stockholm, approximately 30-33 km from the food bank´s warehouse. The distance between the two location is 12 km. Once the relocation is complete, the food bank will no longer visit both facilities to collect the food, but only stop at the new location.

When arriving to any of the donor's facilities, the food bank's truck was always parked outside the warehouse, away from the shipping docks area. Distance between the truck´s gate and the dispatching gate of the donor is approximately 10-15m at the old facility and 25-30m at the new facility.

At the corner where the waste food is accumulated, the driver has the complete authority to decide what kind and amount of food to collect. The main criteria are the BBD and food popularity based on the driver's knowledge, while considering the capacity of the truck. The driver is a professional coach who has the role to educate trainees at the food bank, and has been trained on safe food handling before starting the work.

The social organizations

The food bank redistributes food to 13 social organizations. One of them picks up the product by itself directly from the warehouse and the remaining 12 are visited according to the weekly delivery schedule shown in Table B.2 in Appendix B. Most of the organizations are located in the center of Stockholm. The person responsible for each organization is allowed inside the truck to select the products needed.

4.2 Traceability practices at the food bank

The Donor

The batch number and the BBD provide key information to identify the products if a recall is triggered, however the systems put in place keep managing much more information e.g. name of product, country of origin if applies, or slaughtering place. The system utilized is interlinked with the DC´s system, which means that the donor does not have to register the tracking information again since it was done previously by the DC. The donor just accepts the goods in their system. The information is kept in the systems at minimum 24 months. The donor does not perform test of the robustness of the traceability system since it solves quality related issues frequently.

The donor receives notifications of incidents from the customers which are managed via the customer service department. A weekly report is generated by the quality manager which helps to trigger a red alarm to the chain if some pattern is identified e.g. bad taste perceived in some products. For the past nine years since the store started operating, the donor has never experienced any alarms to recall chicken back due to *Salmonella.*

The donor identifies the products that can be donated by labeling the roller racks with the name of “Matbanken”. The roller racks are placed together with other food waste at the corner of the chilled room, as described earlier. These products are registered in the system as food waste regardless of being donated or not. There is no document that endorses the physical transfer of the donated product from donor to the food bank. Currently, the donor does not know how many kilograms/volume the food bank receives. When the donor receives a notification of an incident or triggers an alarm, they always inform the food bank in order to avoid further redistribution of suspicious products to the charitable organizations, even if they are not sure whether the suspected product have been donated or not.

The food bank

The operation carried out by the food bank is to receive and to deliver product as soon as possible. Based on the condition that all received products will be donated out eventually, the food bank only keeps records when the product is delivered. The truck driver handwrites on papers what is delivered at every recipient´s location, as well as the temperature of the product measured during the route. To measure the product temperature, as illustrated in Figure B.2 in Appendix B, the driver usually put a thermometer with a metal stick in between two meat packages, which were considered one of the most sensitive products, to record representative measurements of the overall product temperature.

At the end of the day, a report is created manually in excel based on the handwritten information. The report reflects the *in* and *out* product flows by using the following information: the product category (see Figure B.5 in Appendix B), product name, donor name, amount, weight/volume, unit, brand/producer, recipient´s name, amount received and the temperature of one representative product. They stop to record BBD, as the truck driver always makes sure that no products passing the BBD is collected since the beginning.

If some food is unwanted during the delivery route, the remaining food will be stored at the food bank warehouse. The surplus food can either be stored in the chilled room or in the frozen rooms depending on the number of days before of the BBD. If the product, mainly meat, has only one day before the BBD, it will be frozen to extend its shelf life. If the product has at least 2 days before the BBD, it is placed in the chilled room in order to deliver it again as in the fresh state. The product will be thrown away under two circumstances: 1) if it has reach the BBD and 2) if it remains more than 3 months in the freezer and no organization needs it.

The product besides from the frozen, e.g. fresh products stored in the chilled room, is not registered until its delivery and no inventory is controlled. However, the frozen food is registered in which the freezing date is recorded, and the frozen inventory is tracked and monitored. Once a week, the food bank sends a list of available frozen food to recipients and delivered them according to the pre-orders.

Currently, the food bank has to manually transfer data from handwritten notes to electronic files in excel, which is both time-consuming and prone to errors. Improve the information recording is one of their future plan. Jonsson (Personal communication, February 1, 2017) commented that:

> *"We are planning for a digital register system for handling both registering products into the food bank from donors and delivering products from the food bank to the receiving organisation, thus saving both a lot of time for the driver and minimizing the risk of error in handling information regarding products."*

The social organizations

Each social organization receives a delivery report from the food bank via email which describes the products that were delivered. The food is used as the main ingredients to prepare meals that will be given or sold at a low cost to vulnerable people. The person responsible of the kitchen records information related with the ingredients such as product name, quantity, batch number and precedence (donated or bought) and also records the temperature during cooking processes.

4.3 Quality practices at the food bank

The food bank followed national industry guidelines for frozen and chilled food standards (Föreningen Fryst och Kyld Mat, 2016), which are, in some parts, more stringent than the regulations. From the field observations, quality-associated activities performed at different steps are summarized in Table 4.1.

Table 4.1 Activities performed by the food bank for the cold chain quality

When	Quality related activities
Before loading	Cool down the truck as low as possible, sometimes below 0ºC
Loading from the donor	No temperature checks upon receipt, only visual inspection Minimize waiting time for loading meat products by prioritization
Unloading to recipients	Random temperature checks Keep a plastic curtain closed to maintain cold airlock inside
Storing at food bank	Manage stocks of frozen foods by First-In-First-Out policy

During loading process at the food bank, the driver prepared the products by prioritizing the cold products to be taken out last as to minimize the waiting time. The frozen food with a pre-order confirmation was stored in an insulated cabinet, pre-chilled inside the freezer a few days before delivery date. During the route, the temperature control for the refrigerated truck was set by the driver's judgment to be quite low especially before any loading/unloading. Sometimes, the temperature was manually set to as low as -16ºC to speed up the cooling process, though the actual temperature would never drop down to that. Nevertheless, the displayed temperature below 0ºC was detected on certain occasions. Within the truck, an insulated cabinet was used to store frozen products when present and was kept at the innermost location, while the meat racks were placed randomly.

No temperature check was performed when retrieving food from the donor, only visual inspection. However, at least two random temperature checks on the food were conducted throughout the route. The driver usually put a thermometer with a metal stick in between two meat packages, which were considered one of the most sensitive products, to record representative measurements of the overall product temperature. The temperature was checked before dispatching, though documentation of the temperature record/reading was sometimes ignored when the displayed temperature was well below the controlled limit of 4ºC.

During unloading processes at different social organizations, the plastic curtain at the truck door was kept closed most of the time to lock the cold air inside the truck when the food was being selected.

As mentioned previously, the food bank does not record stock of fresh products. Only the freezer stock was monitored and managed with a First-In-First-Out policy, which came from the BBD as the product was moved to the freezer one day prior to the printed BBD to extend its shelf life.

Regarding the organizational structure, no routine instruction or manual for quality management is available yet. Jens Jonsson mentioned that they are in the process of putting together a “Egenkontrollprogram”, a control system for food quality, safe handling, and good hygiene concerning foodstuff, including the Hazard Analysis and Critical Control Points system (HACCP), based on European guidelines and national regulations. (Jonsson, Personal communication, February 1, 2017)

4.4 Temperature data

The field test was conducted to collect temperature data for the chicken redistribution chain during March 20-24, and May 2-5, 2017. The test was performed mainly at the food bank and its direct partners, the donor and the recipients. The storage temperatures at the food bank and at the donor were monitored to show the controlled environment where the chicken was temporarily kept. Every day, sensors were attached to the chicken packages, which travelled in the refrigerated truck through a delivery route, to study the critical points during this redistribution chain. However, being a non-profit organization working with charitable activities, the quantity of food received was unpredictable. It was not certain that they would receive the chicken everyday. With the limited amount of time to conduct the test, it was inevitable that different types of meat were used as a study object on days when no chicken was transported. This will be clearly identified in the results with icons as illustrated in Figure 4.3. It is also good to note that the length of temperature monitoring varied at different locations due to experimental constraints. During the test, interruption of data transmission between the sensors and the recording devices (the mobile phones) sometimes occurred, causing information loss at certain periods of time. However, the temperature trend can be observed from the available data points.

Figure 4.3 Different types of chicken and other meats used in the study

Among the three cold storages of the food bank, as previously presented in Figure 4.2, only the meat cold storage, in coupled with the freezer, was involved in the test. The test targeted at a dedicated zone established for the food bank.

4.4.1 Temperature data collected on March 20-24, 2017

During the period of data collection, the donor had just relocated their warehouse to the new location as previously mentioned. As a result, the route was slightly adjusted with one additional stop for the food bank to pick up food from both new and old locations. Only the new facility was allowed to be inspected for the cold storage temperature. However, to have more samples monitored during transport, the sensors were placed on chicken received from both locations, since there was a limited amount of food donated from the new warehouse.

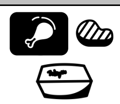
Furthermore, the donated chicken was directly picked up from the display shelf at the new facility instead of the waste corner, which was their normal practice at the old location. Picking from the display shelf was a temporary action during the transition period. Nevertheless, to measure the surrounding temperature of the chicken as accurately as possible, the chicken display shelf was selected as the optimal test-location during the data collection on March 20-24, 2017.

At the food bank, four sensors were placed in the meat cold storage, displaying the mean temperature of 2.7ºC in estimation. The actual temperature data, as shown in Figure C.1 in Appendix C, fluctuated in a repetitive pattern ranging between 0.8ºC to 4.3ºC on most occasions, with random peaks where the temperature could rise up to 6.4ºC. Since the food bank may freeze some chicken to extend its shelf life, the freezer room's temperature was voluntarily monitored during this field test. Similar to the cold storage, the data revealed a pattern of fluctuation, refer to Figure C.2 in Appendix C. The mean temperature was estimated at -18.9ºC in the freezer, which could cool down the surface temperature of the incoming chicken to be below -18ºC in a day.

At the donor's new warehouse, four sensors were placed near the chicken display shelf as mentioned earlier. Majority of the temperature data varied between 0ºC to -2ºC in most locations, except the one on the front right where the temperature shifted up by 1ºC in approximation, refer to Figure C.3 in Appendix C for the graph.

Every day, the route started from the food bank's warehouse, moving to the donor's new location and old location before delivering to 3-6 recipients and ending at the food bank. The quantity of chicken sent from the food bank from the beginning of the route varied considerably due to availability, and most of the time the chicken was in a frozen state. When arriving at the donors' locations, the sensors were placed on the donated chicken inside the facility, which would soon be moved to the refrigerated truck within a few minutes. It is worth to note that the sensors, due to their initial internal temperatures, require a couple to several minutes to match with the chicken temperature. This part of the cooling process is included in the temperature data at the points of food receptions from the donor, where unusually high temperature can be detected in the temperature graph. The donor's storage temperature, as presented previously, can be used to speculate the donated chicken's initial temperature since the chicken usually stays inside the facility for 4-5 days. Table 4.2 summarizes the chicken temperature inside the refrigerated truck during 5-day test.

Table 4.2 The temperature data in the refrigerated truck during 5-day test in March 2017

	Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**
Types of objects being sensed	Crates, pallet				
Max. temp* Min. temp	11.0ºC -10.8ºC	6.1ºC 0.3ºC	6.9ºC -0.2ºC	10.7ºC -1.6ºC	6.3ºC -0.2ºC
Time interval when temp exceeds 4ºC	9-12 min	5-18 min	21-34 min	3-17 min	2-12 min
Any frozen food?	No	No	Yes	Yes	No
**Note: Exclude the cooling phases of the sensors. Check following figures for full detail.*					
Total time when the truck door is opened for loading/ unloading & time for total route					
Load&unload (min)	-	106	78	73	123
Total route (min)	-	388	289	384	360

The atmospheric temperature during day time (9AM – 3PM) on March 20-24, 2017 was between 2ºC-9ºC. The following figures display the temperature data on Day 3 and Day 4, where the highest length of time the chicken temperature exceeds 4ºC and the highest maximum temperature experienced. Even though Day 1 shows higher maximum temperature as well as minimum temperature compared to others, there was no chicken available on that day and the route was unexpectedly cancelled after arriving at the donor's location due to a flat tire. For further investigation, the temperature data of Day 1, Day 2, and Day 5 can be found in Appendix C.2. As an illustration in the temperature graph, the grey truck icon is used to indicates major loading/ unloading processes at the food bank.

On the third day (Day 3), as shown in Figure 4.4, frozen food was dispatched out from the food bank. The chicken temperature varied for different donating locations. Inside the truck, the chicken received from the old location (#69, #71-72) were placed on the roller rack adjacent to the rack where the chicken from the new location (#64) were stored, but further to the truck door. The exact positions inside the truck can be found in the same Figure. In most of the transport duration, the fresh chicken was maintained between 0ºC to 4ºC, with a brief period the temperature fell out of this range. However, one chicken displayed the temperature slightly above 4ºC for longer than 30 minutes. The frozen chicken kept in an insulated cabinet showed the temperature between -20ºC to -16ºC until delivered.

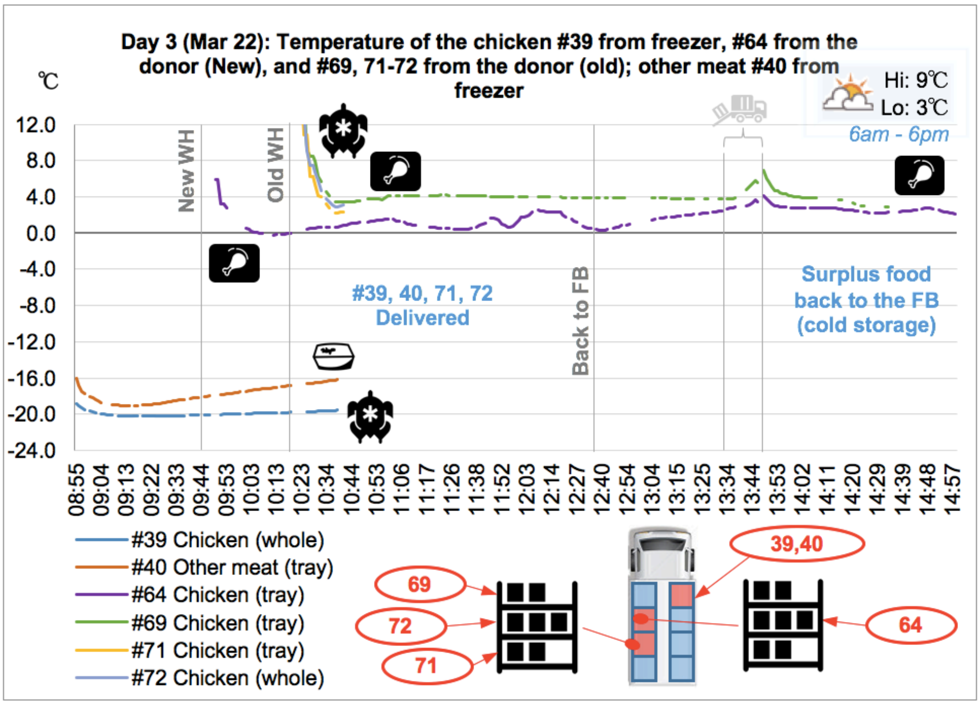


Figure 4.4 Temperature data during the route on March 22 (Day 3)

Figure 4.5 shows the temperature data on the fourth day (Day 4). The temperature of the chicken fillet (#71) exceeded the maximum control limit of the cold chain, which was 8ºC, but only for a short period. The chicken fillet (#71) was placed on the meat rack situated right next to the truck door, and was exposed to sunlight when the door was opened. In the majority of the time, the temperature varied between 0ºC to 4ºC for fresh meats. However, the periods where the temperature dropped below 0ºC can be observed.

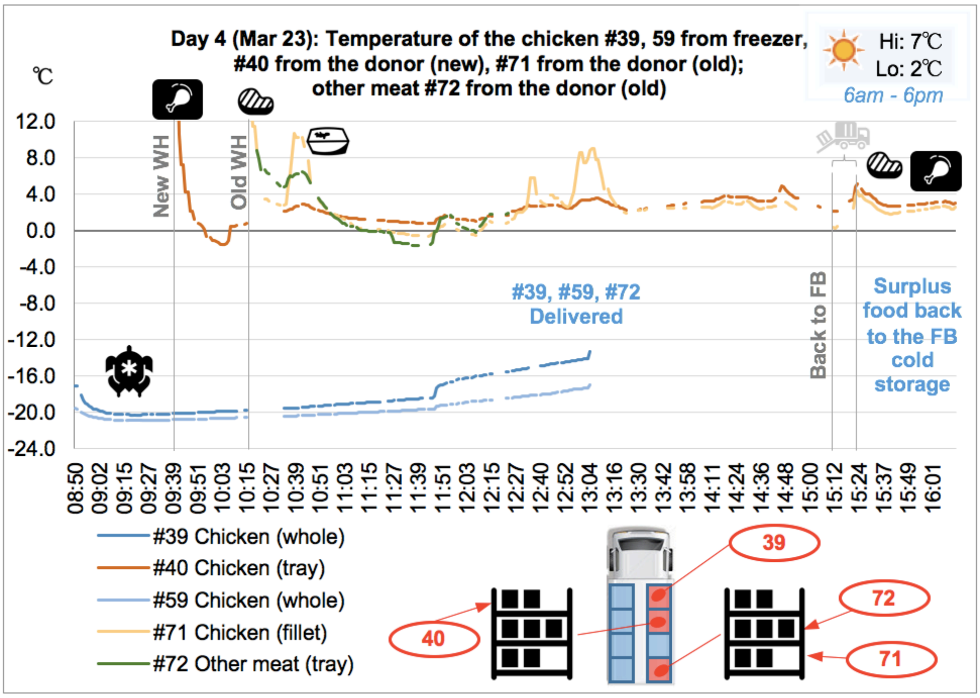


Figure 4.5 Temperature data during the route on March 23 (Day4)

Sometimes, the fresh chicken repeated the route without delivery as shown on Day 5 (March 24), Figure C.6 Appendix C, where fresh chicken was dispatched from the food bank and returned again.

In order to collect the chicken temperature until it is actually prepared for consumption, the temperature monitoring continued at one charitable organization who normally receives the chicken from the food bank. The fresh chicken (#55, #56) were handed over to the recipient on Day 2. They were put in the freezer and brought out to thaw in the refrigerator one day prior to cooking. To overcome the uncertainty of donated food received, which complicates meal planning, the organization generally uses the meat after one week of delivery to ensure the availability of raw ingredients. The received meat would either be in the frozen state or fresh, which would be transferred to the freezer immediately at their location. For the purpose of testing within a shorter time frame, the chicken fillets (#55, #56) stayed in the freezer for only one day, instead of a week, before brought out to thaw.

At the social organization, the chicken surface temperature dropped to -20ºC within half a day inside the freezer. Once moved to the refrigerator for thawing, the temperature rose up to 0ºC and stabilized for more than half of the thawing process. The chicken displayed the surface temperature of 0ºC at the moment before it was being cooked. Refer to Figure C.7 in Appendix C for the temperature data. The core temperature of the cooked chicken was measured to be 84ºC by the chef at the organization.

4.4.2 Temperature data collected on May 2-5, 2017

The situation on May 2-5, 2017 was the same as in March 20-24, 2017 in which the relocation of the donor warehouse was still taking place. Both old and new warehouses were visited for collecting donated food. Thus, the field test in May was conducted in a similar manner as in March. The only exception was the location of the sensors placed inside the donor's new warehouse. Previously, the sensors were placed near the chicken's display shelf, whereas this time they were placed at the waste corner since the donor started to accumulate waste food, which partially could be donated, into one corner for the food bank's personnel to pick up.

Compared to the results in March, the temperature data inside the cold storage and the freezer at the food bank exhibited similar conditions. (Refer to Figure C.8 and C.9 in Appendix C) At the donor's new warehouse, four sensors were placed in the waste corner displaying the air temperature of the area the donated food was temporarily stored, as shown in Figure 4.6. Until 8AM on May 5, most sensors showed the average temperature of 3.4ºC, except one sensor (#60) placed adjacent to the door opening. After 8AM on the last day of monitoring, the temperature rose progressively from 3.5ºC to 6.4ºC within two hours and the sensors were removed from the wall. The cause of temperature rise was unidentified by the authors.

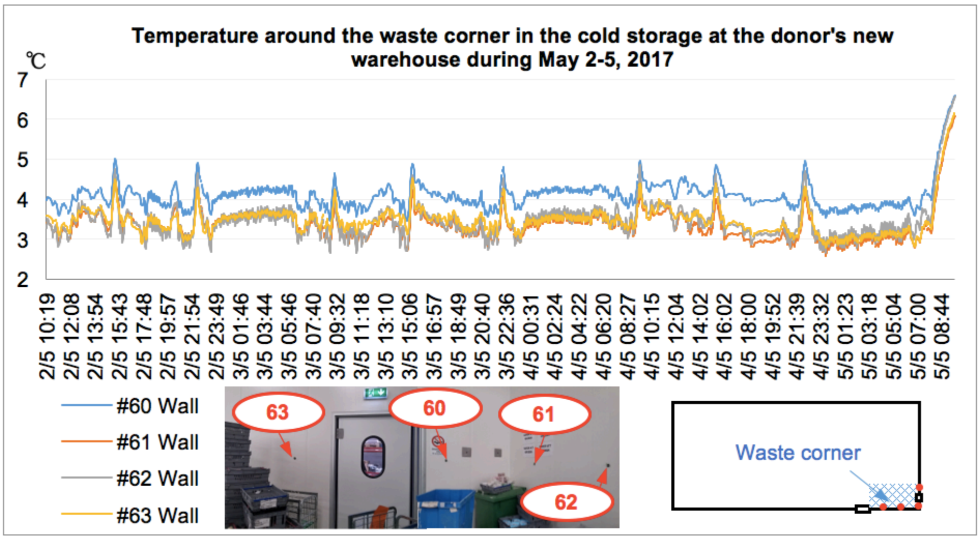


Figure 4.6 The temperature data in the waste corner at the donor's new warehouse during May 2-5, 2017

The delivery route of the food bank remained unchanged in May. Table 4.3 summarizes the fresh chicken temperature observed during the routes on May 2-5, 2017. To minimize the cooling periods of the sensors as experienced during the tests in March, the sensors were pre-cooled with an icepack before arriving at the donor's warehouses.

Table 4.3 The fresh chicken temperature in the refrigerated truck during 4-day test in May 2017

	Day 1	Day 2	Day 3	Day 4
Types of objects being sensed				
Max. temp Min. temp	6.5ºC 0.1ºC	7.6ºC 1.2ºC	7.4ºC 1.8ºC	10.8ºC 1.7ºC
Time interval when temp exceeds 4ºC	2 – 42 min	6 – 65 min	9 – 120 min	16 – 103 min
Any frozen food?	Yes	No	Yes	No
Total time when the truck door is opened for loading/ unloading & time for total route				
Load & unload (min)	63	74	88	55
Total route (min)	310	240	300	250

The atmospheric temperature during day time (9AM – 3PM) on May 2-5, 2017 was between 9ºC-19ºC. Throughout the 4-day test, the fresh chicken exhibited the temperature above 4ºC for more than 30 minutes. The following will present the results from Day 3 and Day 4 (May 4-5, 2017) where the highest temperature and the highest time interval were observed. For further information on Day 1 and Day 2 (May 2-3, 2017), the temperature data can be found in Figure C.10 and C.11 in Appendix C respectively.

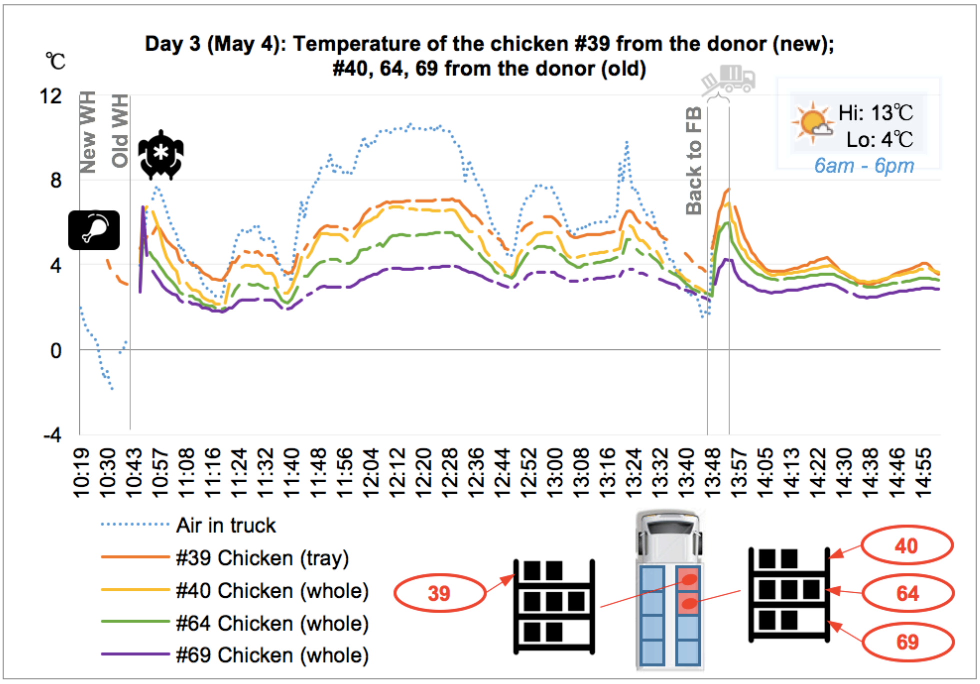


Figure 4.7 Temperature data during the route on May 4 (Day3)

Figure 4.7 shows the temperature of the fresh chicken in the truck on May 4. Air temperature inside the refrigerated truck was additionally monitored and displayed as a dot light blue line. Chicken in a tray (#39) demonstrated a higher temperature when compared to whole chicken (#40, 64, 69). The average temperature of all tested chickens was fluctuating between the range of 3.1ºC-5.5ºC. However, many chickens displayed temperature above 4ºC for longer than half an hour.

On May 5, all the chicken received were whole chicken, refer to Figure 4.8. The exhibited temperature lay above 4ºC during most of the transport time, even though the chicken was placed in the innermost of the refrigerated area. The chicken #63 reached its highest peak of 10.8ºC when it was on its way from the donor's new warehouse to the truck, which was parked outside the building, approximately 25-30 meters away from the gate. There was one rack for loading from the new warehouse on the day, and the loading took around six minutes in total.

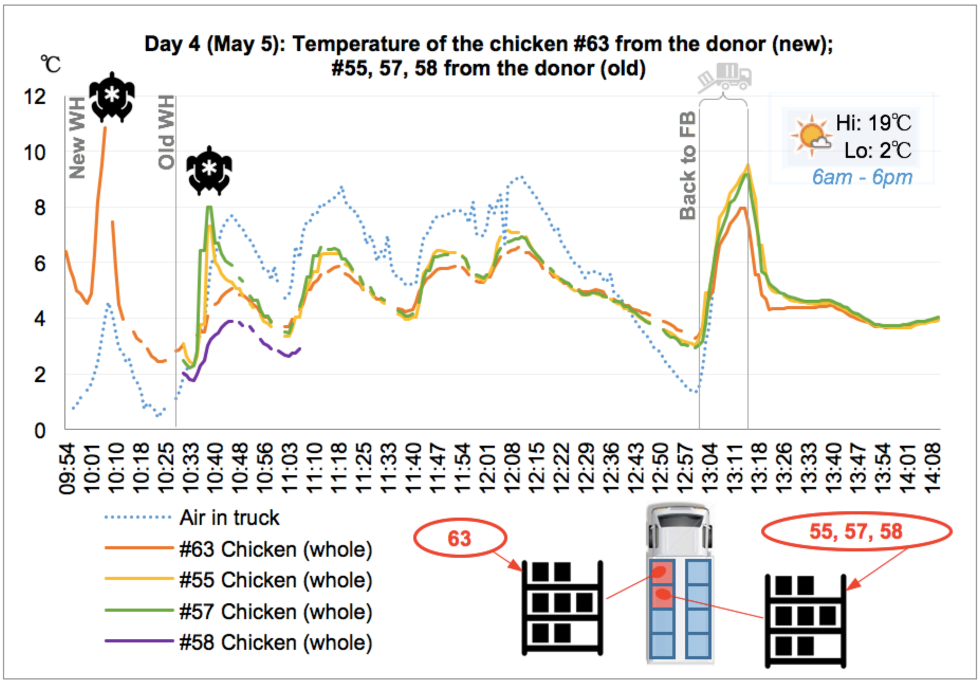


Figure 4.8 Temperature data during the route on May 5 (Day4)

For the test in May, another social organization was selected as a testing location to monitor the chicken temperature until it is consumed. Similar to the organization tested in March, the chicken is brought out from the freezer to thaw in the refrigerator one day prior to cooking. Inside the freezer, the temperature of the chicken decreased to -16ºC at minimum. After being thawed for almost a day, the chicken temperature reached 3ºC before cooking. Refer to Figure C.12 in Appendix C for the graph.

4.5 Upstream actors of the chicken food chain

In order to understand any potential risks incurred on the food before it arrives at the donor, as shown in the blue line in Figure 4.9, the upstream part of the chicken food chain was explored via interviews from different actors in Sweden. It is to be noted that the interviewees participated in the research were not restricted to the actual chain partners of Stockholms Stadmission's food bank.

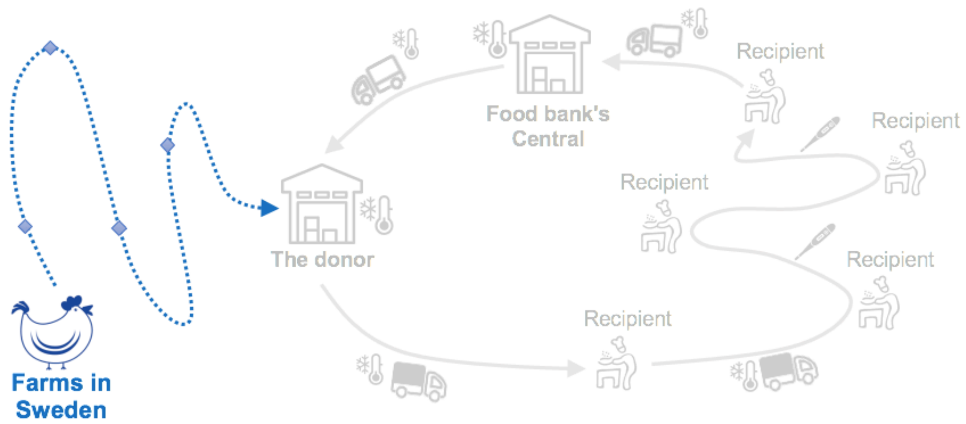


Figure 4.9 Journey from the Swedish farms to the Donor

The chicken food chain starts from farms where chickens are bred, eggs are hatched, and chicks grow. 5-10 week old chickens are sent to slaughter, which will then be processed for different types of finished products, e.g. whole chicken, chicken fillet, seasoned chicken, etc. Most of the chicken will be delivered to the DC, disseminating the products further to its downstream chain, generally to retailers where the chicken is sold to end consumers.

Along this chain, the cold chain starts at the point between slaughtering and processing. The cold chain has to be maintained and uninterrupted until the end. The interviews with regards to traceability practices and quality management were performed with actors from different tiers, starting from broiler farms to retailers, as presented in Figure 4.10. The investigation started at broiler farms who involve in production of poultry for meat, or where baby chickens are raised. Breeder farms and hatcheries, which are the steps before broiler farms, are excluded from the interview. Retailers represent actors from an equivalent tier with the donor in the case study, despite diverse working conditions.

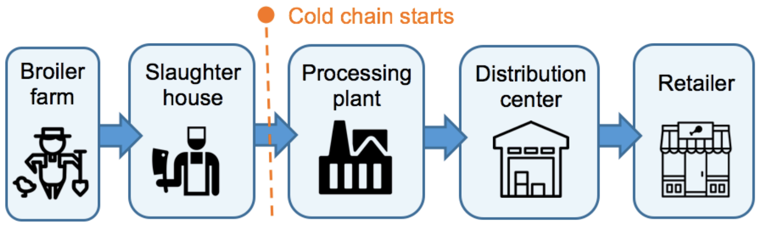


Figure 4.10 Upstream actors of the chicken food chain

Farms

The interviewed farmers perform different practices since one produces organic chicken and the other produces conventional chicken. For both farms, chicks arrive from the hatchery on the same day that they are hatched. New-born chicks are placed in a "welcome" space with the initial controlled temperature of 35ºC, and will stay there for the next 3 weeks. During this period, the room temperature will gradually be reduced down to 18ºC, more or less depending on the relative humidity percentage (RH%), as the chicks grow and feather out. Then chickens are moved to the stable –where they may go in and out as they like- by transporting them in boxes. This operation is done manually during the night because the chickens are calm and are easy to collect. The growing period of organic chickens takes longer time than the conventional chickens. From the interviews, the organic farm grows chickens for 70 days, while the non-organic farm spends 52-56 days for this process. However, both exceeds the industry requirement, which asks for 5 weeks or around 35 days at minimum. At the end of growing period, chickens have reached the weight demanded by the Swedish consumers, approximately 2 kg. Then they are sent to the slaughterhouse during the night.

The internal control points are the temperature and RH% of the spaces as well as the health of the chickens since the antibiotics are avoided. These variables are checked at least twice a day. The organic farm applies vaccine PARACOX®-5 in order to avoid illness of coccidiosis (i.e. a parasitic disease of the intestinal tract of the animals). The non-organic farm reduces the number of birds/m^2 by half, if compared to the general requirement of 16-18 birds/m^2, in order to avoid sickness transmission due to the congestion of chickens. Required by the chicken industry, *Salmonella* is tested approximately ten days before slaughter to ensure Salmonella-free. If a chicken is sick or injured, it is killed immediately to avoid infection. For organic farms, there are external controls from the KRAV`s auditors and the municipality's environmental inspectors. The feed purchased is organic since it comes from a KRAV certified producer and it is *Salmonella* controlled as well.

Related to traceability, the group of chickens that arrive the same day from the same hatchery are marked as a batch. The farm has not received notification of problems related with the chickens that they produce.

Slaughter and Processing

The slaughterhouses in Sweden only receive *Salmonella*-free chickens which is checked ten days before slaughtering. Slaughtering, deboning and cutting and processing, which may include seasoning, generally take a very short time. Some companies who use an automatic production line for chicken can complete this whole process within 90 minutes from the moment the chickens are fed to the slaughter-table. In other companies, the operations are mainly performed by humans, requiring warmer environmental condition for workers. To minimize microbial growth under these operating conditions, the processing time is even shorter than the automatic line. The temperature control starts right after slaughter where the chicken must be cooled down immediately either by water or air. Some companies have an additional step of meat tenderizing between slaughter and cutting, by cooling the meat between 0-4ºC for 24 hours. The meat is then taken out to be cut, seasoned if needed, and packed within 15 minutes under the operating temperature of 6-8ºC. The finished products are stored in the cold storage, where the temperature is maintained at 1-4ºC, before dispatching to customers within 0-2 days.

Multiple microbial tests are performed during the process. The tests mainly check for *Salmonella, Campylobacter, E. coli, Staphylococcus*, and *Listeria*, depending on each company. While some companies focus on performing the analysis during slaughtering process, the others pay more attention to analyze on the finished products. The microbial tests generally take 2-day lead time. Hence, the possibility of the test result arriving 2-3 days after delivery is present. During those period, the chicken might be consumed before any recalls are activated. However, if the chicken in question is cooked appropriately, there is no health concern.

Some companies only use a third-party logistics service provider for transportation, while some have their own fleet. The transportation time can take up to 10 hours on the road. However, if hiring a third party, the length of time can be extended to 24 hours as it includes storing at transportation hubs in addition to the time spent on traffic. The third party is contracted to maintain the temperature limit of 4ºC for fresh chicken and -18ºC for frozen chicken until the point of destination. Batch number and/or BBD and/or time stamp provide essential information for traceability. In some companies, the batch number reflects the production date, while it can reflect the farm origin in other companies.

Most of the Swedish chicken companies are certified under Svensk Fågel, which provides the quality standard for all the actors in the chain. This hallmark acts as a valid certification for quality and is widely accepted in Sweden, thus no further documentation is required from customers within the country.

As a producer, the company is responsible for setting the shelf-life of the products. Based on the assumption that the temperature is maintained at 4ºC uninterrupted, the shelf-life of the fresh chicken is set with some buffer e.g. 2-4 days extra.

Based on the past experiences of the interviewees, the company scarcely experiences any big recall incidents in relation to suspicion of food-borne illness in chicken. However, upon receiving random customer complaints, though rare, suspicions of cold chain break in the downstream are detected.

Distribution Center

The DC receives the finished products from the processors. In case of imported products, microbiological prove is requested. To ensure quick-turnover of perishable food like chicken, the amount of product received is equal to the orders to be delivered to the retailers, which means that no additional chicken is stored. The lengths of time the chicken stay in the facility vary between 0-2 days. In order to assure the good practices that will have an impact in product quality, the Logistic Management System (LMS) is utilized, additional information of LSM may be found in section D.2 in Appendix D.

The chicken temperature must be between 0-4ºC at the receiving point and this range has to be maintained during all the activities performed in the warehouse including transportation and delivery. The measurement of the core temperature is done by using a “needle” thermometer which sometimes is inserted inside the product. The IR-thermometer is used to check the truck's interior temperature and the surface of pallets for instance. The temperature in the warehouse area is controlled between 0-2ºC for fresh products´ handling, including receiving-picking-dispatching areas. The storage temperature for the frozen products is below -26ºC. During transportation, the temperature inside the vehicle is continuously monitored by the Fleet Management System (FMS). The trucks are controlled between 0-4ºC for fresh products and at least -18ºC or lower for frozen products. If a truck encounters a problem (e.g. mechanical problem) during the transportation route, the procedure is to evaluate the impact of damage on the food. If the cold chain is broken (over 4ºC), the product has to be destroyed, otherwise it is transfer to another truck. With a solid infrastructure and control mechanism, the DC does not face any difficulties maintaining the quality of the cold chain even in summertime.

The warehouse utilizes the Warehouse Management System (WMS) for the receiving-put away-picking activities and the Warehouse Control System (WCS) for automated material handling equipment. Systems help to track and control all data registered within the storage for at least the 24 months as regulation requests. The information traced are: batch number, BBD, quantity, weight, each delivered load carrier to the retailer, temperature of the vehicles, temperature inside the warehouse, each and every location inside the warehouse where the product has been moving during the time, data on the specific type of load carrier the goods was received. When a red alarm is notified by the producer, usually the batch number is utilized to identify and quarantine the product. The DC notifies the problem to the retailers, while the suspicious product is automatically locked in the retailer system, which means that when any persons is purchasing that product at the cashier, the system does not allow to sell it.

Related to challenges faced in the DC´s chain to maintain food safety and quality, the interviewed person stated that “*One of the most critical aspects would be that we do not follow the common routines and processes at some point or that some of our sub-suppliers such as transportation or Cross-Docking facilities do not follow our agreed routines.*”

Retailers

At the retailers, a random temperature check is performed on the incoming chicken by inserting a thermometer between packages. The maximum allowable temperature is 4ºC for fresh chicken and -18ºC for the frozen. After delivery, the chicken is usually sent directly to the display shelf unless there is no available space, and stays there for slightly over a week at maximum. However, some retailers temporarily store the receiving chicken, together with other groceries, in the cold storage at 8ºC-10ºC for less than 2 hours, before transferring the chicken to the display shelf. The temperature setting in retail display is 3ºC for fresh chicken and -20ºC for frozen products. The temperature inside the display shelf is continuously monitored. If a certain level of time-temperature abuse is detected, a warning alarm will be sent directly to the store manager’s mobile phone.

The BBD of the products are checked every morning. If it has reached its printed BBD, it is immediately removed out from the display shelf. Since the meat is still good to eat based on printed BBD, instead of throwing the meat away, some stores cook them and sell as a prepared food. While some stores offer the product by half price.

When a certain batch of chicken gets recalled from the upstream, the DC will register the batch in the central system, sending an alarm message to retailer in which employees need to periodically check from their computer. However, if the employees miss to take an immediate action to remove the quarantined chicken out from the shelf, the barcode of that batch is locked preventing any purchase from cashiers.

5 Discussion

This section discusses the results presented in the preceding chapter with the help of the theoretical framework described previously. The aims of this part is to answer the formulated research questions and draw a conclusion.

5.1 The food bank and its partners

Challenges in managing the cold chain

According to the cold chain assessment model proposed by Raab et al. (2008), inter-organizational cold chain characteristics and temperature data have now been identified for the redistribution chain in the previous chapter. The presented results reveal weaknesses and challenges faced by the food banks and its partner, demanding for control measures which will be discussed as following.

From the field tests, the displayed temperature of different types of chicken varied due to differing packaging and mass, dictating heat transfer properties of the individual product. The tray of chicken usually showed more fluctuating temperature data than others as a large air gap sometimes presents between the chicken meat and the sensor. Despite aiming to conduct the test under the most natural conditions, due to uncontrollable inputs for different types of chicken received from different locations within a single route, it is hard to determine the best cold spot in the truck. However, the chicken placed at the top level of the rack experienced stronger effects from temperature variation than at the middle and the bottom, as clearly observed on the test on May 4. This finding is also mentioned by Raab et al. (2008) and Rediers, Claes, Peeters and Willems (2009).

During the test in March 20-24 where atmospheric temperature was between 3ºC - 7ºC during most delivery periods, the displayed chicken temperature varied from -1.6ºC - 10.7ºC. While the range of 0.1ºC to 10.8ºC was observed on the test in May 2-5, the ambient temperature ranged from 9ºC - 19ºC, which was much higher than March. However, the maximum temperature detected on the chicken in March is almost equivalent to the maximum temperature shown in May, and even exceeded its surrounding air temperature. The unusual spike resulted from the chicken fillet being placed near the truck door and exposed to direct sunlight during door opening.

When the fresh chicken or other types of meat products are left from the route, it will either be stored in the food bank's cold storage or the freezer depending on how far it is from BBD. This implies that some fresh meats need to repeat the delivery route a few times before they are delivered for consumption, generating a higher chance for temperature disruption, like the result from March 24.

As identified by many studies, loading and unloading processes are main critical points in the cold chain, due to the lack of a cold airlock at dispatching and receiving areas. (Göransson & Nilsson, 2013; Olsson, 2004) The loading/unloading gates are designed to keep the proper temperature in the cold chain and to avoid cross contamination. However, during the delivery of the food bank, there is no temperature controls at any stop. The docking station at the food bank´s warehouse is not equipped with any cooling system. When arriving at the donor's warehouses, the truck was parked outside the building, approximately 15-30 meters away from the gates, which means that the driver is obligated to move the roller racks containing the food one by one from the warehouse, passing through the parking zone to reach the vehicle. Once all racks are ready by the side of the truck, the truck´s gate is opened to start the loading process. This practice avoids the interior of the truck from being exposed to the external temperature for a longer period of time, but on the other hand, it jeopardizes the cold chain and it exposes the products to cross contamination. As seen from the field test, high temperature rise could be detected on the chicken during the test in May, even for a brief period of loading from the donor locations. The process did not last more than 13 minutes. If the proper loading/unloading gates were utilized, it would help secure the cold chain better.

Unlike any other actors in the supply chain, the food bank is challenged with a certain uncertainty of the food received and delivered. At several delivery stops, the workers from the social organizations entered the refrigerated truck to check what is available and selectively pick the food they need. The truck door was left opened during the food selection process, which varied from 5-21 minutes. Sometimes, more than one person went in to check the food inside the truck, bringing more heat from outside as well as generating heat from their body temperature.

Moreover, as most of the recipients are located within the same proximity, a short drive between each stop does not permit enough time for the refrigerating system to cool down the area inside, before the truck door is opened again for another unloading, as observed in the test on May 5. The temperature of the chicken escalated higher and higher through different stops, until it rose above the control limit for a period of time. This activity of food selection significantly exposes the food to vulnerable conditions in the food bank´s chain. However, with the new truck the food bank has ordered, which is built with one additional small door on the side, this problem should be alleviated to a certain degree as it decreases the area of the air flow.

As the food bank transports everything together in one truck, from dry products to chilled products and even frozen products, the temperature is compromised in the combine transport and the legal limit is 8^{O}C in the cold chain. The compromised temperature negatively impacts the quality of certain types of food since each food demands a different optimal temperature (Olsson, 2004). During the route, the driver aimed to maintain the temperature below 4^{O}C as to ensure the safety of the sensitive products like meat. However, sometimes the temperature dropped below 0^{O}C which could cause partial frosting inside the meat, deteriorating food quality in terms of the texture and feel when it is consumed. Though, no harm is established in terms of food safety.

The regulated limit of 8^{O}C for the cold chain, though accepted by law, does not provide the optimal condition for the chicken. When the producers set up BBD for the chicken, they test under the assumption that the temperature is maintained at 4^{O}C, and a buffer of 2-4 days is added to the printed BBD. However, this buffer is depleted faster if subjected to temperatures higher than 4^{O}C. It is not certain how this condition has been violated through multiple storages and distributions before reaching the food bank who lies at the far end of the chain. As indicated in many previous studies, sharing temperature data between supply chain partners is crucial to ascertain food safety throughout the cold chain.

At the donor location, the food close to BBD is separated and gathered in one corner where the food bank's personnel independently pick the food at their own discretion, and the remaining food would be thrown away. This may create another vulnerable point if some of the donor's personnels move the food to the waste corner while being unaware that the food could be used for donation. It might cause temperature disruption during handling due to negligence. When measuring temperature at the waste corner in May, the temperature was comparatively higher when compared to March. However, it was maintained at good level for most of the sensors between 0-4ºC, except the one next to the door where air flux was strongest. There was one peculiar temperature rise on the last day where the temperature kept increasing with unknown reason. This will potentially affect food quality inside the warehouse. The presence of this kind of unexpected event highlights the importance of temperature monitoring and sharing even further.

At the social organizations, the fresh chicken was treated professionally during the test. It was thawed in the refrigerator for one day and cooked until the core temperature exceeded the safety guideline. However, a freezer at one of the recipients was not able to cool the meat down to -18ºC. Reliability of cooling units should be constantly inspected to ensure healthy temperature control at all social organizations. Table 5.1 summarizes all the key discussions above.

Table 5.1 Summary of findings from the field tests

General findings
• Different types of products entailing different packaging have varied thermal properties, resulting in diverse displayed temperature • Chicken placed on the top level of the rack experienced highest temperature fluctuation
Challenges identified in the food bank's redistribution activities
• Successive door openings when unloading food to recipients located in close proximity • Extended door opening times for food selection process at each delivery stop • Food is handled in the smallest unit size e.g. single carton of milk instead of one box with multiple cartons, potentially increasing handling time if food is delivered in a number of small units • Unpredictable in both food received and delivered, resulting in surplus food left from the first delivery route. Some food has to repeat the route again before actually delivered, increasing risk of time-temperature abuse • No cold airlock at any loading and unloading locations • Combined transport can cause cross contamination, especially when all food is in the smallest unit, e.g. a tray of fresh chicken, where damage of packages can easily occur due to less protection from secondary package • Over-chilling below 0ºC reduces the quality of a certain type of food, though produces no harm in term of food safety • No communication on temperature data from the donor • Reliability of the cold storages at its membered social organizations

Challenges in traceability aspect

In term of traceability practices, the food bank handles all the record and provides summary reports to the social organizations. As mentioned in the empirics, food bank does not keep record of the food coming in to their cold storage, and will only document when the food is delivered out. This is in one way efficient, but on the other hand, data associated with product movement is missing, failing the internal traceability explained by the GS1 standard (2007). This condition may create 1) a risk of product loss if somebody takes food before its registration and consequently a lack of traceability and 2) unavailability of the sojourn time where the food stays at the food bank.

The data record for traceability does not include any batch number or BBD. When any recall incident happens, which is very rare as the products almost reach the end of their shelf life, all the products with the same BBD will be removed out together by visual inspection. This implies that the food bank would need to throw away some good food as they can not identify the exact batch requested to get rid of and communicate to the recipients accordingly. This unnecessary disposal is contradicted to the food bank's original purpose of avoiding food waste. However, with the limited resource at the food bank and considering the amount of food handled at the moment, it might not be worth the effort to keep all the information for the purpose of recalling back the specific batches. Nevertheless, with the expectation of growing a number of donors, social organizations and volume of products, this missing data may cause inefficiency and error in a long run. The inability to identify from the database whether the suspicious product resides in their facility or not will create more vulnerability to the operations, since it can only rely on human visual inspection which is prone to error with increasing number.

Regarding with external traceability practices, the principle of *"one step up, one step down"* described by GS1 (2007) standard is not being fulfilled entirely. The ability to trace a product back, or one step backward, is possible since the information is clear in each actor i.e. the donor, the food bank and the social organizations possess clear information of what product they have received. However, the ability to identify the direct recipient of the specific traceable product is weak in the donor side since it registers both waste and donated food altogether as "waste food", without recognizing how much volume and to which organizations the food is donated to. There is no delivery receipt between the donor and the food bank. Refer to Figure 5.1 for illustration.

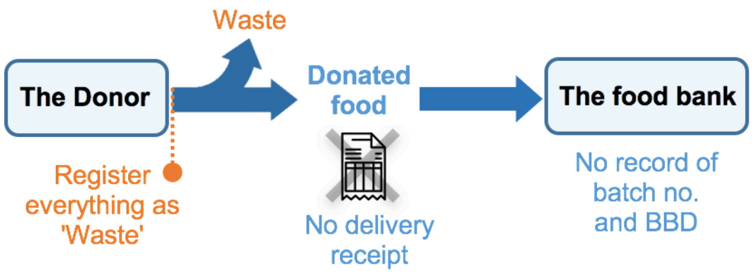


Figure 5.1 Illustration of data record between the donor and the food bank

In general operations, the food bank activity is physically performed by a dedicated driver, from storing, selecting, and transporting. All the processes are handled by one personnel. Education and training to the driver, as well as the substitute, is thus highly important. Maldonado-Siman, Yamazaki-Tanabe, Kreyenschmidt, and Diaz-Hernandez (2015) highlighted *"the work experience and training of drivers"* as *"a major strength"* contributed to the quality of the cold chain.

5.2 The upstream part

After analyzing the far-end of the cold chain, the food bank and its immediate partners, the discussion will continue to evaluate potential time-temperature abuse in the beginning of the chain. The interview results from different actors are summarized in Table 5.2 for discussion.

Table 5.2 Summary of the chicken chain in Sweden from farms to retailers

Actor	Process	Sojourn time	Main quality concerns
Broiler farm	Growing chicken	5 – 10 weeks	Hygiene and infection
Short-distance transport			
Slaughterhouse	Slaughtering	21 – 45 min	Microbial contamination
Processing	Meat tenderizing*	24 hours	Microbial growth and contamination; temperature control
	Cutting* – seasoning* – packing	15 – 45 min	
	Storing and distributing	0 – 2 days	
Transport up to 10 hr. drive on road; or up to 1 day if a logistic service provider has a temporary stop at its transportation hub (may subjected to combined transport)			
Distribution	Storing, sorting, and distributing	1 – 2 days	Time and temperature control
Combined transport: 1-20 hours			
Retailer	Storing and selling	Up to 8-10 days	Time and temperature control in display shelves

*Note: * indicates that the process is optional*

Food safety and quality practices

In Sweden, most of the chicken industry is represented under Svensk Fagel, which guarantees that all the chickens are *Salmonella*-free and antibiotic use is restricted (Svensk Fågel, 2007). The country has virtually eliminated *Salmonella* from poultry and poultry meat (Svensk Fågel, 2010). However, in recent year, increasing cases of *Campylobacter* infection have drawn attention in Sweden, causing chicken actors to react to this new threat and provide better control. Råd & Rön investigated fresh chickens and found *Campylobacter* in all slaughterhouses in Sweden except the one from Bjärefågel and Knäred ("Från ägg till file", 2013). How they breed and grow the chickens at farm level significantly influence the growth of bacteria and disease in chickens. From the interviews, the industry requires 5-week time to grow chickens at minimum. Though some farms allow the chickens to grow at a slower pace. The typical fast growing prevents the chickens to build up any immune system to fight the disease, causing the chickens to be more vulnerable. Besides from the growing speed, farmers also identified the level of congestion in stables as another influential factor for healthy chickens. Bjärefågel provides more space for the chickens to roam around, less congested by half if compared to the industry requirement. This might be the reason why Råd & Rön found positive results from the farm. However, no specific cause is identified yet.

In slaughterhouse, the slaughtering process is carried out without delay to avoid contamination of meat. After which, the meat must be cooled down immediately to not more than 4ºC before proceeding to other processes. This is where the temperature control for the cold chain is activated and must not be interrupted until the end. During the processes after slaughtering until finished products are acquired, maintaining hygiene and time-temperature control are critical to food safety. Microbial testing provides an indicator for the quality of the chicken. Many producers take frequent samples of the finished products for microbial testing, while some focus on performing the test during in-between processes e.g. cutting, seasoning, etc. As the microbial test typically takes two days, it is possible that the result arrives after delivery since the finished products does not stay with the producers that long, 0-2 days. This can be a loophole for dispatching infectious chicken to markets. However, per the informant, scarcely does the company have to activate a recall of chicken due to a suspicion of infection. Moreover, to be certified under Svensk Fågel or other Swedish quality certificates, chicken industry players have to follow stringent controlled requirements which demand relatively high standard. It could be assumed that the chicken produced in Sweden are in good quality.

From the point of dispatching from producers, the chicken goes on a journey through transporting, temporary storing, sorting, and distributing for approximately 2 – 4 days before it arrives at retailers. During this product transferring and handling by subsequent actors from logistic service providers, distribution centers and retailers, Olsson (2004) has indicated concerns that can potentially break the cold chain as following: combined transports, mixed temperature zones in dispatch and loading areas, waiting times at dispatch and loading, several stops at retail, and limited food knowledge. To check the quality of the chicken sold in the supermarkets in Sweden, Råd & Rön (2013) sampled chickens and tested for the presence of *Campylobacter* and *E. coli*. They found *Campylobacter* in the chicken from Coop, Eldorado, Ica, Lagerbergs, Garant, Gyllda, Bosarps; and *E. coli* in the chicken from Coop, Guldfågeln, Lagerbergs, Garant, Gyllda, Bosarps, Bjärefågel and Knäred ("Från ägg till file", 2013). Icakuriren also performed a similar test in 2013 and found one out of three samples from Kronfågel unacceptable as the number of *E. coli* exceeded the maximum limit (Ottosson, 2013). From these microbial testing on chicken sold in retailers, producers suspected the cold chain was broken somewhere in the downstream.

From the interviews, temperature checks are generally performed at the transferring points between different actors, or specific to the points of product receipts, but not always during the processes e.g. transporting, storing, etc. However, certain companies had clearly indicated that continuous temperature monitoring was used during the transportation between the producers to the DCs, and between the DCs to the retailers, as well as in the display shelves at the retailers, as shown in Figure 5.2. This can somehow guarantee the safety in most part of the chicken cold chain.

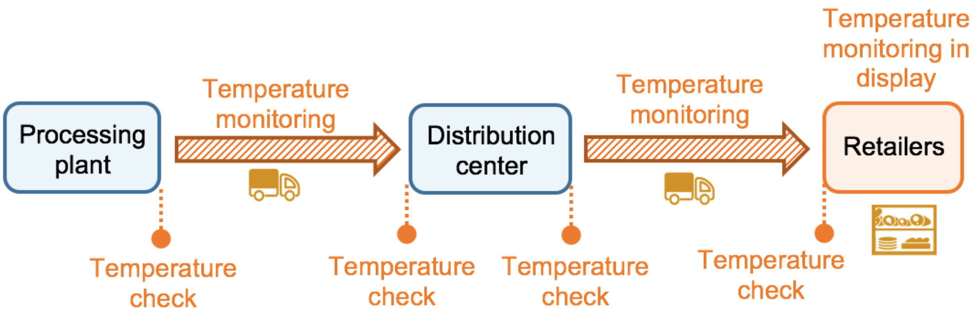


Figure 5.2 Temperature inspection in chicken cold chain

Nevertheless, one retailer had revealed that they temporarily stored the chicken in the cold room at 8ºC-10ºC for less than 2 hours before putting them on display shelves. This time-temperature abuse exceeded the regulated limit and would deteriorate the meat quality, putting retailers to be a weak point in the chain. Even with the temperature monitoring in the displays as mentioned earlier, Göransson (2017) still found displays in retails as a challenge in maintaining the cold food chain in Sweden. Retailers are the location where the chicken tend to spend the longest time in the whole chain and thus expose the chicken to more vulnerability especially from customers.

One of the interviewees from the DC also expressed the concern that they and/or their sub-suppliers sometimes did not follow the routines and processes at some points, even though they had working instructions in place. This emphasizes the importance of education and training to workers who work in the cold chain. As identified by Olsson (2004), lack of knowledge about food hazards can be one of the reason why workers do not follow instructions, jeopardizing food safety practices.

When determining BBD for their chicken, manufacturers generally add an extra buffer e.g. 2-4 days on the printed BBD. This is based on the assumption that the temperature is maintained at 4ºC at every level. Thus, a limited period of time that the cold chain breaks is acceptable. However, it is hard to determine how much buffer has been depleted along the chain if no documentation of temperature loggers is available and shared between partners. As the chain advances further to the end, knowledge about temperature exposure previous in the chain becomes even more critical. (Olsson, 2004)

Traceability practices

In term of traceability, the four-pillars model of Regattieri et al. (2007), shown in Figure A1 in Appendix A, is fully applicable in the upstream chain. All the actors use batch number in coupled with BBD as a common product identification across the chain. The batch number can be interpreted differently at different chicken producers. Some may reciprocate with production date, while others indicate the farm origin. The data to trace includes not only where, when, and how much the chicken is received and processed, but also all other input ingredients like spices as well. All activities performed are documented in case investigation is requested e.g production activities and movements or storage activities. Many actors conduct either periodic drill tests or actual product recalls to ascertain the robustness of their tracing systems and declare no issues or concerns regarding traceability.

The use of traceability tools systems is crucial in the good performance of the traceability within the supply chain. When some incident occurs that compromises the consumer´s health, the ability to react in a timely manner is a key factor to minimize the negative impact as much as possible. The better and more precise the tracing systems, the faster an actor within the supply chain can identify and resolve quality problems. Technical solutions such as the European Article Number (EAN) codes is the most utilized. The upstream actors work with different systems (e.g. WMS, WCS, FMS) capable of storing the information for at least 24 months, capable of providing temperatures in real time inside the transport vehicles or capable of tracing the movements of the goods over time within the warehouse or within a transformation process among others. The effective communication among the actors is crucial to tackle any red alarm successfully. The distributions centers and their retailers are very well connected technologically, which allows them to react in a short time to solve the issues if any incidents occurs.

6 Conclusions

This section concludes with the answers addressed to the research questions and suggestions developed for the food bank regarding a control measures to ensure food safety. It ends with contributions of the thesis to society, industries and academia.

6.1 Conclusion of the study

The following main conclusions are drawn from each section that comprises this thesis work.

- The food bank is a newly established concept in Sweden. It is treated as a normal food business operator who needs to follow the European and Swedish food regulations.
- A fundamental traceability system allows to trace both the product and the activities involved. However, the food traceability system guarantees its reliability only when product identification, data to trace, product routing and traceability tools are all present. Then, the traceability management across the supply chain is achieved.
- In the cold chain management, time-temperature is the most important environmental factor to control due to its impact over the microbial growth and, consequently, over the food quality. For this reason, it is crucial not to break the cold chain.
- Field tests were performed by monitoring the temperature of the product during the transport in the cold chain in Stockholms Stadsmission´s food bank and its partners (the donor and the social organizations), in order to identify critical points where time-temperature abuse occurs. The results were: 1) lack of airlock at all loading/unloading zones, 2) successive door openings when unloading to social organizations located in close vicinity, 3) improper parking space for the food bank´s vehicle at the donor´s facility, 4) unreliable cold storages at the social organizations. This concludes that the food bank should exert more stringent measures to overcome these challenges. Some ideas for improvement are suggested in the following section.

- It has been seen that food safety in the food bank´s redistribution chain is manageable and is guaranteed thanks to the low complexity of its operations. In the case of a potential inclusion of new actors and/or a growth in the amount of donated food, traceability practices should be strengthened otherwise food safety may be compromised. It is worth solving this area of opportunity before the complexity arises.
- Interviews were carried out to the upstream actors of the Swedish poultry chain -from farms, slaughterhouses, processing plants, distribution centers and retailers- in order to understand the traceability and quality practices they perform, and to assess potential risks that might cause the cold chain break in the upstream. It was found that the actors were aware of the importance of traceability as a tool that allowed them to act quickly when facing any quality problems. This awareness was shown in good documentation practices at every single step of their processes, the utilization of management systems and modern interlinked technology that improved the communication between them. In term of the cold chain management, continuous temperature monitoring was exercised in a certain parts of the chain. Though a concern of workers failing to follow routines were still present, the quality of the chicken cold chain in general was well-managed.

6.2 Suggestions to the food bank

From the critical points identified during redistribution activities from the donor to the social organizations, some suggestions are developed for the food bank regarding its control measures;

- To set the maximum temperature limit in the truck to be 4ºC, not 8ºC as law permits, especially when fresh meat is transported. Considering that most of the products almost reach its printed shelf-life with unknown time-temperature abuse in previous actors, further temperature violation should be minimized
- To keep the refrigerating unit of the truck on while loading/ unloading if necessary
- To add a temperature buffer if possible, especially during summer, by lowering the temperature of the cold storage at the food bank that could bring the chicken temperature down to e.g. 0 – 2ºC, rather than close to 4ºC
- To consider the possibility to transform all fresh chicken to frozen and transport in the frozen state, to avoid greater risk of transporting fresh meat during summer. If possible, have the fresh meat frozen since the donor location.
- If possible, cooperate with the donor to 1) allow the food bank's truck to park at the proper loading area, 2) avoid putting the donated food near the

door opening inside their warehouse, 3) share information on the list of waste products via electronic data to facilitate product tracing of potentially donated food, 4) to request the delivery receipt

- Provide sufficient education and training to develop knowledge on food safety and food hazard to workers and volunteers
- Periodically request the social organizations to check the storage temperatures to ensure its reliable performance in maintaining the proper temperature level, and reemphasize the importance of constant training on safe food handling as there might be new volunteers working in the organizations
- In the future, if the number of donors has increased, more robust traceability tools should be prepared: i.e. clear product identification, registration of product movement. Also, if the new donor happens to be supermarkets and is willing to give away fresh meat, an evaluation of display shelf temperature is recommended.

6.3 Contribution of the study

This Master´s thesis is novel by reflecting how traceability is a very important tool in order to ensure food safety and the quality of donated food -close to its BBD- redistributed by food banks.

This work contributes to the initiative launched by the UN -within the seventeen Sustainable Developed Goals- aimed to reduce food waste by 50% before 2030 since the proper functioning of a food bank represents a path to achieve this goal.

Stockholms Stadsmission´s Central Food Bank benefits from this thesis due to the fact that 1) it reflects how the food bank currently performs the traceability within its cold chain and 2) it provides suggestions aimed to tackle the identified challenges for a low and a potential high complexity within its operations.

It is an important topic for both the industry and academia. For the food industry by reflecting how each actor plays its own role in order to ensure food safety and the quality of their products. For logisticians and those who are involved in the supply chain management area, this work helps to understand how the whole Swedish chicken food chain is prepared in order to tackle adversities, such as product recalls, for example, thanks to an effective traceability using crucial interlinked management systems for timely communication among the various actors.

Finally, for academia the novel topic presented serves as a precedent for continuous research in traceability, food cold chain, charitable organizations and the applicability of one of the major innovation within the food supply chain which is the Bluetooth Low Energy sensors for time-temperature monitoring.

7 Suggestions for further studies

In order to develop a deeper understanding and provide a meaningful indicator of quality on the food donated through the food bank for charity organizations, it is recommended to continue study in the following areas;

- Perform the field tests to collect temperature data in summer time, during Jun – Aug, in order to better identify critical points under the most severe environmental condition
- Extend the field tests to collect temperature data to other actors in the supply chain, from producers until retailers, in order to investigate temperature exposure at all levels
- Incorporate microbiological shelf life prediction models of the chicken to mathematically evaluate the remaining shelf life of the meat based on reality-based time-temperature data
- Investigate how the end consumers handle chicken at home

These suggested studies would help ensure food quality and safety delivered to the social organizations, and potentially reduce food waste created from unnecessary disposal by identifying the actual remaining shelf life which may exceed its printed date.

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Appendix A Traceability and quality theory

This appendix presents the Regattieri et al. (2006) four pillars framework which supports the performance of the food traceability system as well as the critical points identified in the food supply chain (Olsson, 2004).

A.1 Four Pillars Framework

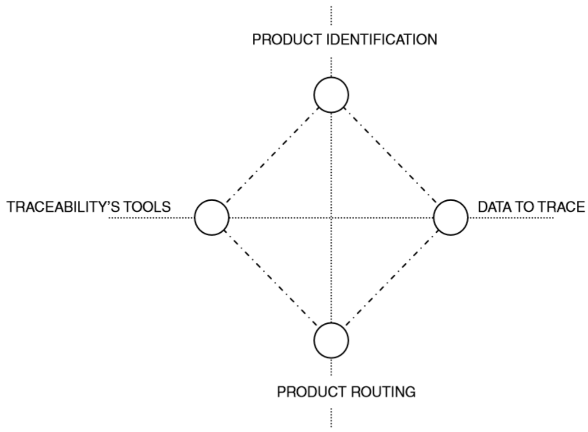


Figure A.1 Traceability system framework based on four pillars: product identification, data to trace, product routing and traceability tools (Regattieri et al., 2006)

A.2 Critical points in food supply chain between different actors

Table A.1 Critical points identified in food supply chain (Olsson, 2004)

Critical area	Concerns
1	Product cooling prior to palletizing or loading Lack of temperate air lockage at dispatch Temperature requirements put forward to transporter→ lack of self control Limited food technology knowledge at operational level
2	Cooling aggregate only for temperature keeping – not for cooling Limited documentation of temperature loggers Combined transports Limited or no food knowledge
3	Mixed temperature zones in dispatch and loading areas Waiting times at dispatch and loading Limited or no food knowledge
4	Several stops at retail → heats up cooling area in truck at each stop Return goods heat up cooling area Lack of temperature controlled area for incoming goods Waiting times for unloading Cooling cabinets in retail store not reliable Lack of temperature control
5	No knowledge about temperature exposure previous in the chain No knowledge about validity of "best before date" Different ways of handling food in household Different levels of knowledge about food hazards Different exposure of food at transport from retail to household

Appendix B Food bank chain

The appendix shows the organization model of Stockholms Stadsmission, the weekly food bank´s route, the measurement of temperature performed by the truck driver, as well as the categories utilized to identify the donated food.

B.1 Stockholms Stadsmission organization model

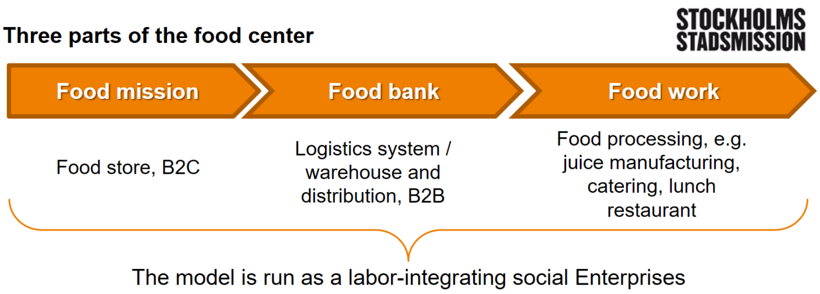


Figure B.1 Stockholms Stadsmission´s food center core enterprises. Translated from Stockholms Stadsmission´s original version.

B.2 Weekly route

Table B.1 Weekly route of the redistribution of donated food.

Route	Mon	Tue	Wed	Thu	Fri
Departure	Central WH	Central WH	Central WH	Central WH	Central WH
Collection	Donor new Donor old	Donor new Donor old	Donor new Donor old	Donor new Donor old	Donor new Donor old
Delivery	Recipient 1 Recipient 2 Recipient 3 Recipient 4 Recipient 5 Recipient 6	Recipient 7 Recipient 8 Recipient 9 Recipient 10	Recipient 1 Recipient 11 Recipient 12	Recipient 3 Recipient 4 Recipient 5 Recipient 10	Recipient 2 Recipient 7 Recipient 9

Collection fruit & vegetables		Grocery (donor)		Grocery (donor)	
Arrival	Central WH	Central WH	Central WH	Central WH	Central WH
Total Route (km)	90.2	89.7	78.9	96.5	83.5

B.3 Temperature measurement in route

Figure B.2 Temperature measurement between two packages.

B.4 Categories of donated products

Table B.2 Categories assigned by the food bank to redistributed products

1	Dairy	4	Fruit/ vegetables	7	Beverages
2	Raw protein	5	Bread	8	Coffee/ Tea
3	Cooked protein	6	Miscellaneous	9	Ready to eat food

Appendix C Temperature data

The appendix shows the results of the field tests performed during March 20-24, 2017 and May 2-5, 2017. The temperature data at different locations and during the routes of redistribution are displayed for further investigation.

C.1 The field tests in March 2017

C.1.1 Temperature data at the facilities

Following figures show the temperature data at the food bank's cold storage, the food bank's freezer, and the donor's new warehouse.

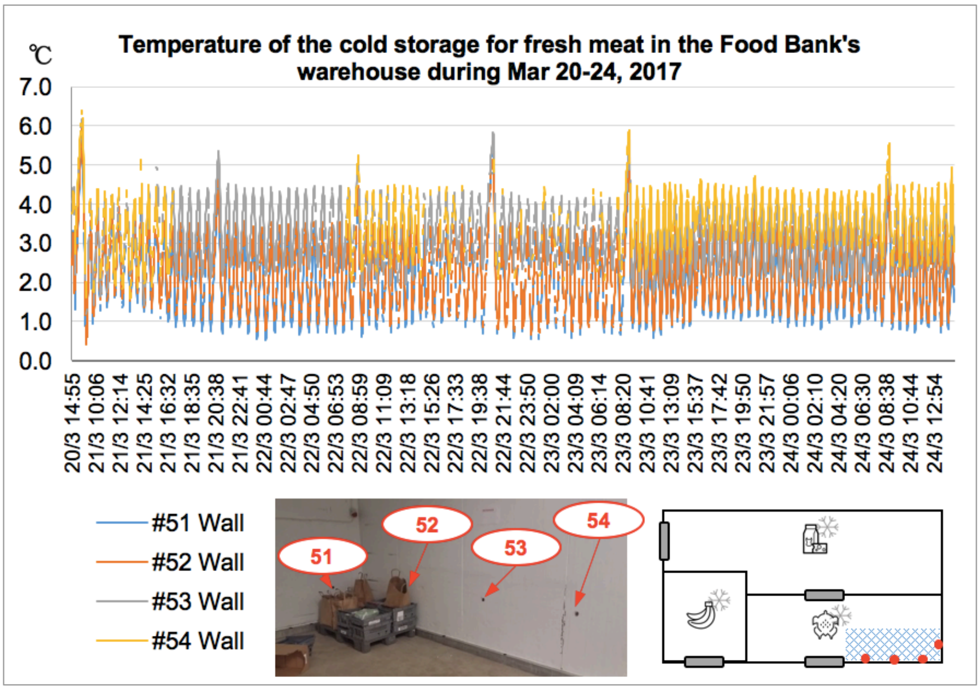


Figure C.1 Temperature of the meat cold storage at the food bank during March 20-24, 2017

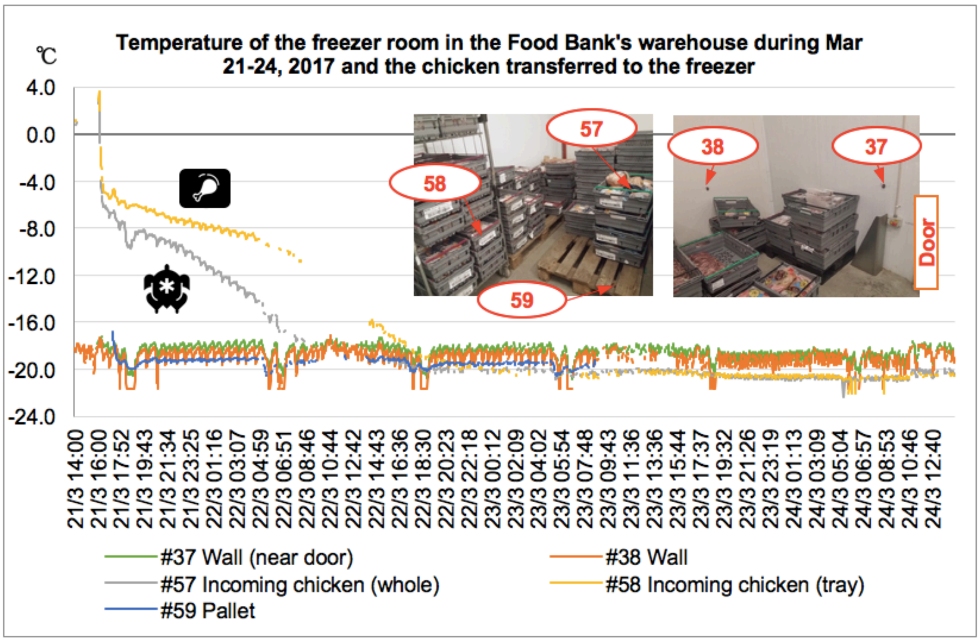


Figure C.2 Temperature of the freezer and the chickens delivered into the freezer at the food bank during March 21-24, 2017

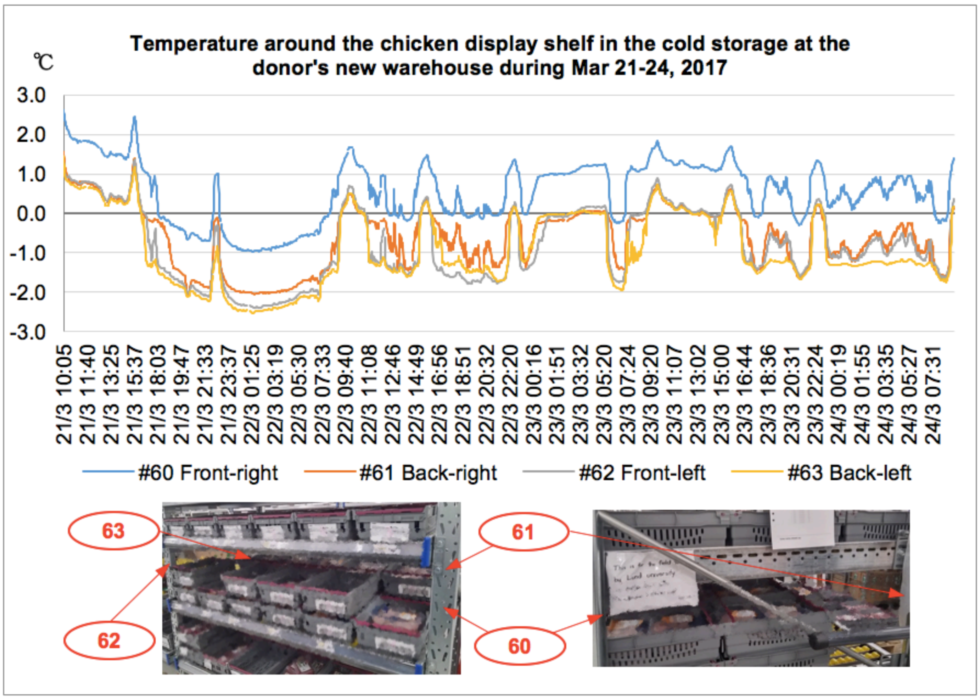


Figure C.3 Temperature of the cold storage at the donor's new warehouse during March 21-24, 2017

C.1.2 Temperature data during and after the routes

Figure B.4 displays the temperature data inside the refrigerated truck on March 20. The sensors were placed on the crates and the pallet since no chicken was dispatched from the food bank. The truck's tires were found flat after loading the food at the donor's location. Consequently, the delivery plan was cancelled for the day, and the food were unloaded and returned to the donor's warehouse.

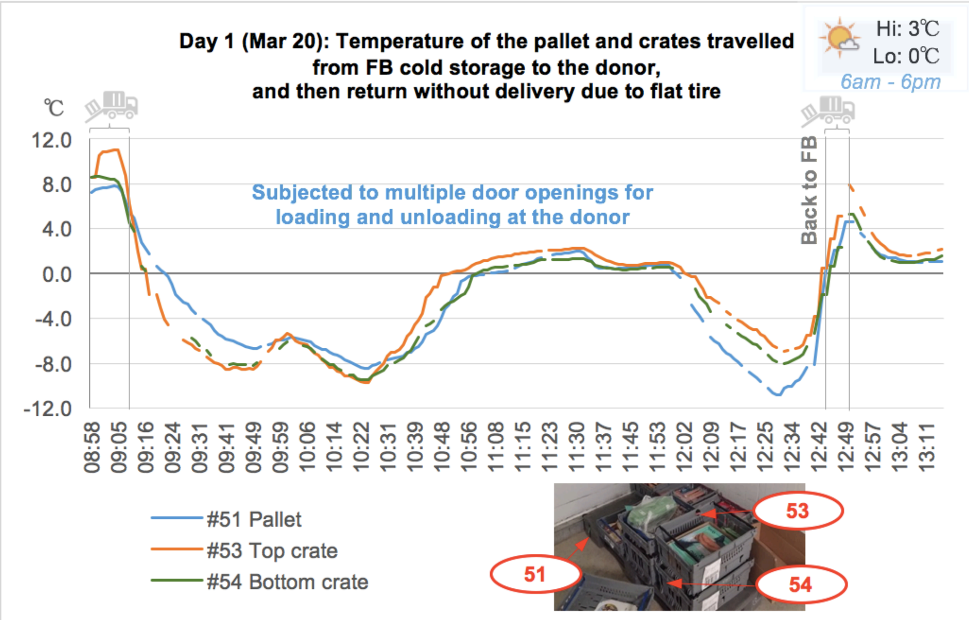


Figure C.4 Temperature data during the route on March 20 (Day 1)

Figure B.5 and B.6 show the temperature data observed on March 21 (Day 2) and March 24 (Day 5) respectively. On March 21, the chicken was delivered to the targeted organization where the temperature monitoring continued until the point the chicken was cooked, see Figure B.7. On March 24, one fresh chicken was sent out from the food bank and returned back without delivery.

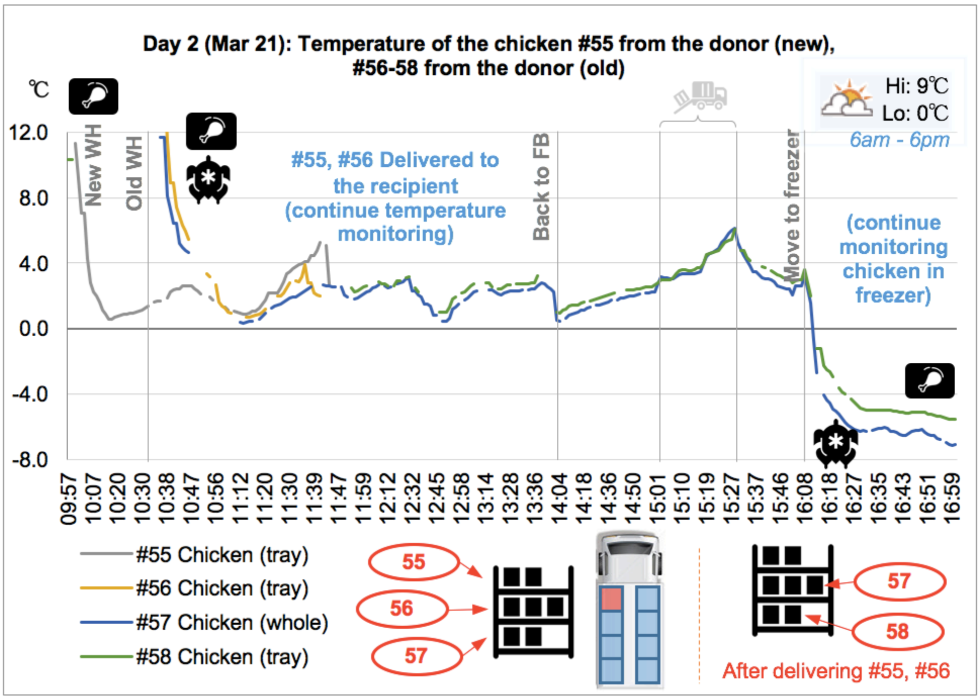


Figure C.5 Temperature data during the route on March 21 (Day 2)

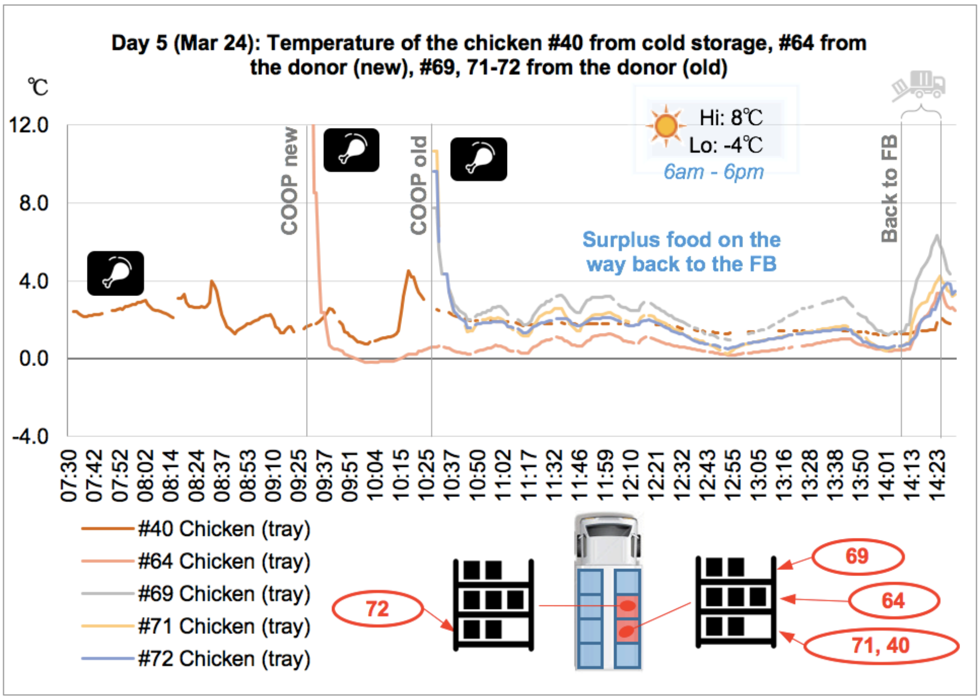


Figure C.6 Temperature data during the route on March 24 (Day5)

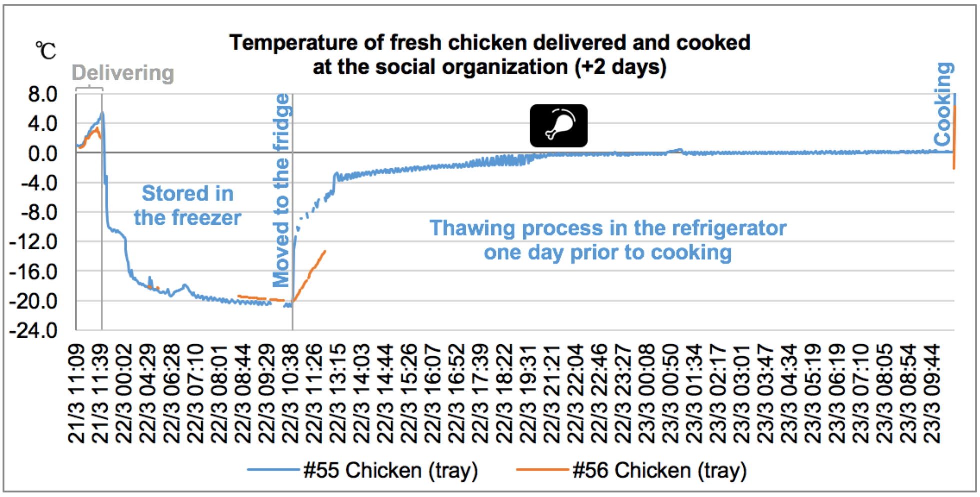


Figure C.7 Temperature of the chickens prepared for consumption at the social organization (A) in March 2017

C.2 The field tests in May 2017

C.2.1 Temperature data at facilities

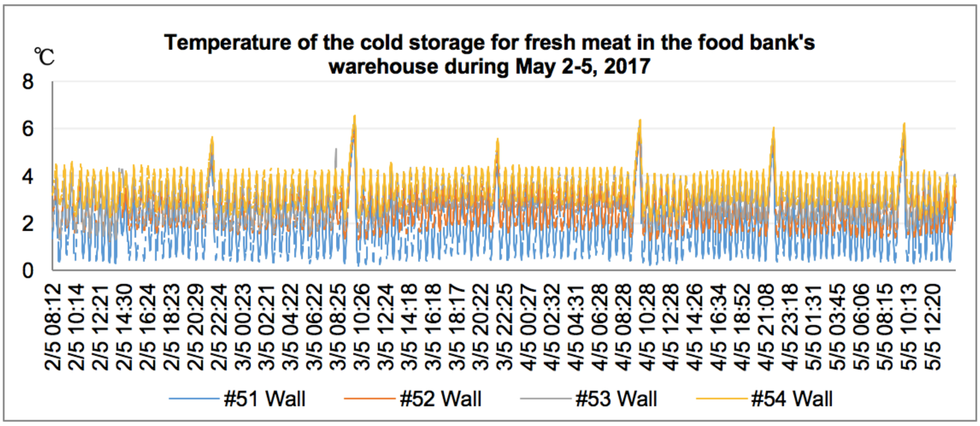


Figure C.8 Temperature of the meat cold storage at the food bank during May 2-5, 2017

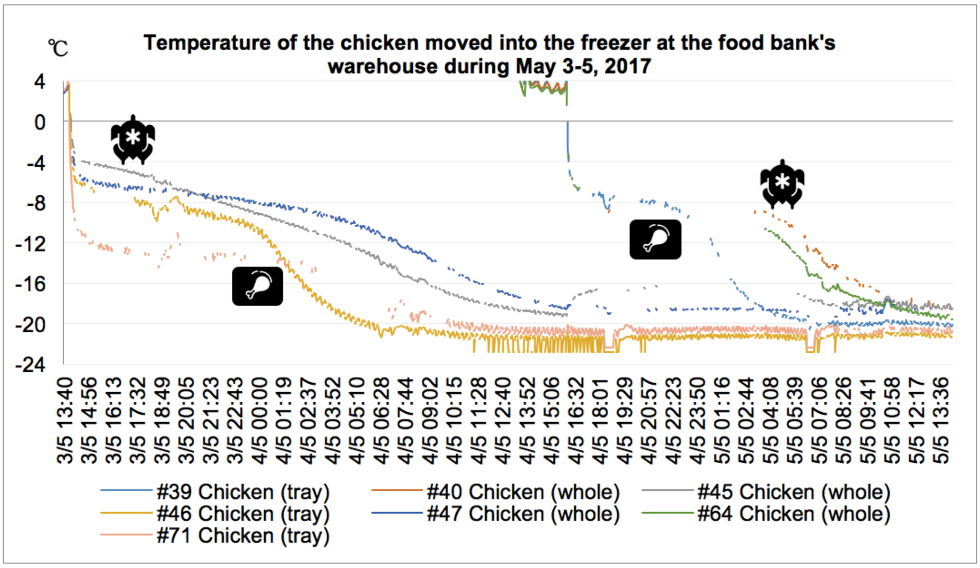


Figure C.9 Temperature of the chicken transferred into the freezer at the food bank during May 2-5, 2017

C.2.2 Temperature data during and after the routes

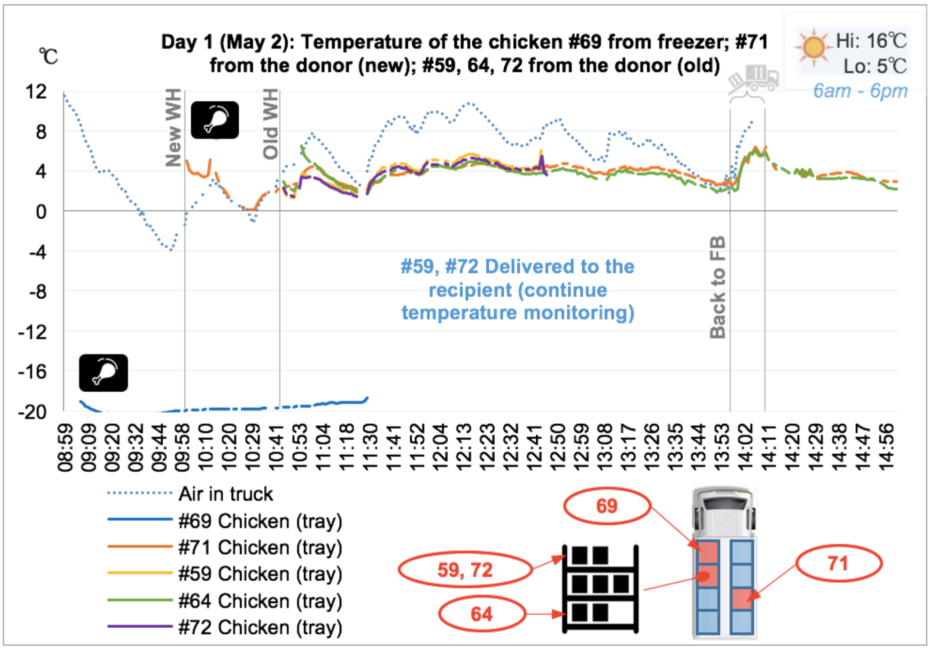


Figure C.10 Temperature data during the route on May 2 (Day 1)

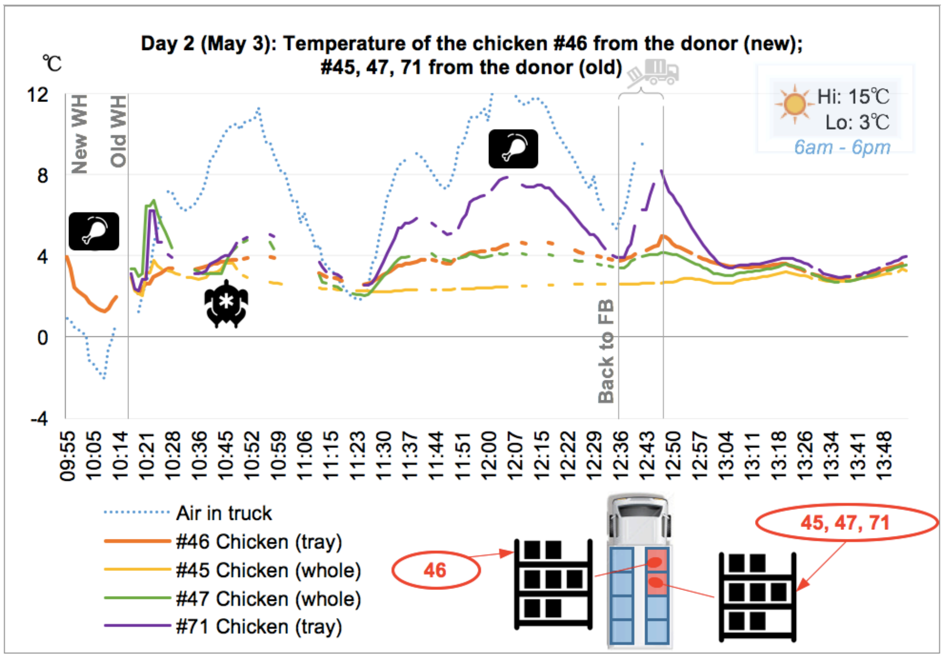


Figure C.11 Temperature data during the route on May 3 (Day 2)

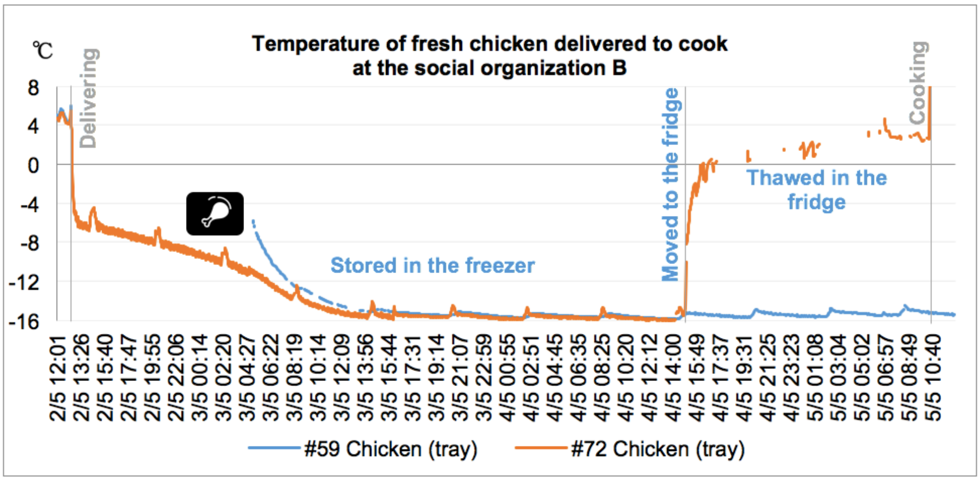


Figure C.12 Temperature of the chickens prepared for consumption at the social organization (B) in May 2017

Appendix D Interview with upstream actors

The appendix shows interview questions which are part of the semi-structured interviews performed with different actors in the chicken supply chain. Summaries of the interview results are also described.

D.1 Interview questions

1. Can you explain your supply chain? Who are the main actors in your chicken chain, and which position in the chain you are? Please elaborate the flow of goods.

<u>Traceability</u>

2. What does traceability mean to you?
3. What information do you trace? (Batch number / Best Before Date / etc.) How do you trace them; do you use any specific system/ routine? (WMS / other technologies)
4. If any incident related to food quality happens, what actions would you (and your partners) take? Any past experience?
5. How do you confirm that your traceability system is robust/ reliable/ efficient? (Any periodic drill test/ simulation) This is to ensure that you would be able to react quickly and effectively when anything happens, if this activity is hold critical to you.
6. How long do you keep traceability records?
7. Is there any challenges you face in chicken traceability?

<u>Quality management in the cold chain</u>

8. What quality checks do you perform: before receiving / during your process / after or when dispatching? (microbial test / temperature check / etc.) Please describe in detail how you perform routine inspections, especially in how do you measure the temperature and the tools (type of thermometer) used.

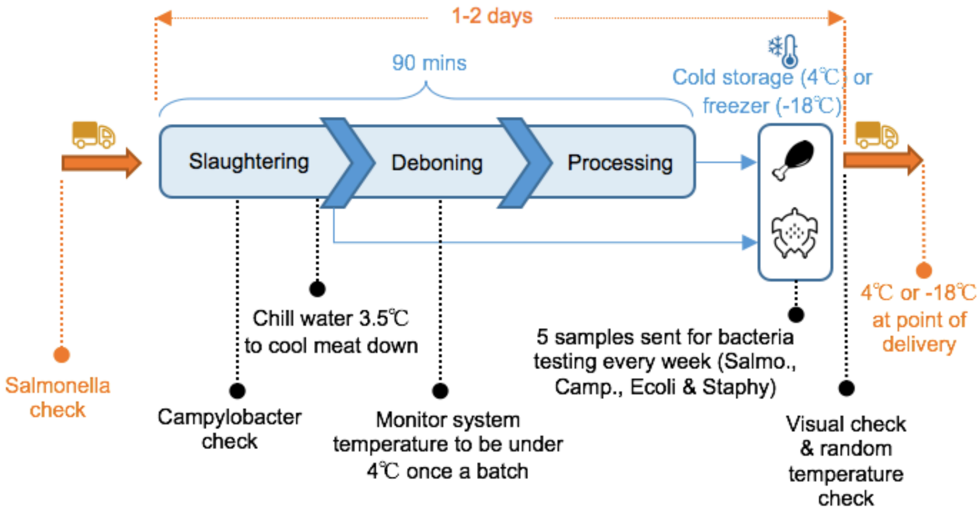
9. For a processing company/ a slaughterhouse, can you describe all the processes that any chicken has to go through once it enters your premise until it leaves? What is the length of time the chicken stays in each process as well as the controlled temperature at each step? How is the quality inspection between each stage?
10. Inside your facility, what is the general controlled temperature/ limit in the common areas? (maximum and minimum)
11. How long does the chicken usually stay in your premise in total?
12. Would (inbound and outbound) transportations be part of your responsibility? If yes, can you approximate the transportation time of your delivery route? What is the controlled temperature?
13. Can you identify any challenges faced in your chain to maintain food safety and quality?

D.2 Interview results

Following are summaries of the interviews performed with different actors. It elaborates more detail of each individual interviewee's response. It is worth to note that some interviewees choose to answer the questions via email, which may limit the extent of clarity.

D.2.1 Company A: Slaughtering and processing

The slaughterhouse receives chickens and processes them within a day. Slaughtering, deboning and processing (including seasoning if required and packing) are conducted procedurally, taking around 90 minutes in total before the packed meats are stored in either cold storages or freezers with the controlled temperature of 4ºC and -18ºC respectively. After slaughter, chilled water of 3.5ºC is used to quickly cool down the meat before it begins the deboning process or is sent directly to packing process, if sold as a whole chicken. The finished products stay at the premises 1-2 days in approximation before distribution. Prior to dispatching for transport by a logistics service provider, a visual check and random core temperature check are performed. The logistics provider is contracted to deliver food with the temperature maintained at 4ºC and -18ºC for fresh and frozen chicken respectively at the point of destination. The batch number associated with packing date and time stamp provide essential information for tracing.



The presence of four bacteria is tested for: *Campylobacter*, *Salmonella*, *E. coli*, and *Staphylococcus*. *Campylobacter* and *Salmonella* are checked for any presence of bacteria on both raw and processed meat, while *E. coli* and *Staphylococus* are counted in number on the processed meat. *Salmonella*, as required by law, is checked on alive chickens 10 days before slaughtering and on the finished products (processed meat). Chicken industry in Sweden that is certified under Svensk Fågel (Swedish Bird) is guaranteed with *Salmonella*-free. (This hallmark also acts as a valid certification to customers, so no additional quality document is required) However, *Salmonella* can be introduced during meat processing from spices or human contamination. *Campylobacter*, an emerging bacteria raising concerns in Sweden, is voluntarily tested during slaughtering process. These two bacteria, including *E. coli* and *Staphylococcus*, are checked again on the finished products (processed meat), which are sampled out for testing once every week. Microbial test generally takes 2 days, which means the result would come 2-3 days after delivery. It is possible that the chicken might be consumed during those period. However, if the chicken is cooked appropriately, there is no issue with health concern.

As a producer, the company is responsible for setting the shelf-life of the products. Microbial count on *E. coli*, *Staphylococcus*, and *Salmonella* is the main indicator of the chicken shelf-life. Based on the testing of 4 ºC, the company usually add a buffer of 2-3 day on the printed BBD.

D.2.2 Company B: Farming, slaughtering and processing

The farm receives new-born chickens and raises for 52-56 days old before sending to slaughter. This slow breeding allows chickens ample time to grow healthily, resulting in better meat quality. The chickens are provided with plenty of space to roam around, double size from the industry’s requirement, which is not only beneficial for chickens' health, but also allows the farmer to be void of antibiotics use. Tests on *Salmonella* and *Campylobacter* are performed on the chickens 10 days prior to slaughter.

Slaughtering process usually takes around 21 minutes, where multiple microbial checks e.g. *Salmonella*, *Campylobacter*, and *E. coli*, are conducted. After slaughtered, the chickens are cooled down immediately with cold air in a shock cooler, and continue to be cooled at 0-4ºC for 24 hours for tenderizing. The next day, the chickens are taken out to be cut, seasoned if needed and packed under the operating temperature of 6-8 ºC for 15 minutes. Finished products are then stored in a cooling room, where the temperature is maintained at 1ºC, before dispatching to customers within 1-2 days. A scheduled test for *Listeria* and *E. coli* is occasionally performed on the processed meats or finished products. For the transportation, the company uses both own transport and logistic service providers to deliver the products, during which the transportation time can take up to 8 hours in maximum. However, if hiring a third party, the length of time can be extended to 24 hours as it includes storing at transportation hubs in addition to transporting. Batch number and BBD provide key information to trace the chicken back to the farm level if needed.

Certified under Svensk Fågel and Svenskt Sigill, the quality is widely accepted among Swedish people. Scarcely does the company experience any recall incidents. However, upon receiving random customer complaints, though small in number, suspect of cold chain break in the downstream is detected.

As a producer, the company is responsible for setting the shelf-life of the products. Based on the assumption that the temperature is maintained at 4ºC, the shelf-life of the fresh chicken is set with some buffer e.g. 14 days instead 10 days.

D.2.3 Company C: Slaughtering and processing

Microbial tests are performed at the stables/ breeders before slaughter. Once slaughtered, the temperature of the chicken is checked before entering cutting area. Multiple microbial analysis is conducted per a control plan (no specific detail).

For traceability purpose, they keep all information from breeders to destinations who receive finished products. The record includes detail of stable/ breeder, slaughter day, cutting day, temperature curve if heat treatment applied, input ingredients, batch, labeling, BBD, mass balance, and analysis certificate.

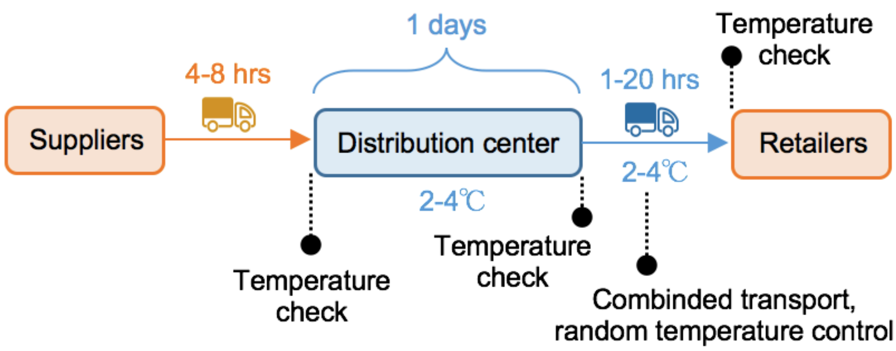
D.2.4 Company D: Distribution Center

The Logistic Management System

In order to assure the good practices that will have an impact in product quality, the Logistic Management System (LMS) is utilized which contains the description of specific methods in order to fulfill the management and the customer requirements. These methods are specified under three different strategies: the logistic and product flow strategy, the logistic and transport strategy and the logistic and warehouse strategy. Each strategy has their own tactical, operative and executive activities.

D.2.5 Company E: Distribution Center

The DC receives the chicken from the suppliers, in which the inbound transportation usually takes 4-8 hours. The temperature check is performed on the incoming chicken, as well as visual inspection for any damage. The chicken only stays at the premise 1-day maximum, before being distributed to the supermarkets/ retailers. The controlled temperature is maintained at 2-4ºC inside the distribution center. Before dispatching, the temperature is checked on the products. The outbound transportation lasts 1-20 hours, where the chicken is transported with other products at 2-4ºC inside the truck. During transport, the temperature is continuously monitored but randomly controlled. Upon arrival at the retailers, the temperature is checked again before delivery. The thermometers used are metal stick type and infrared type, with the maximum allowable limit of 4ºC on surface and core temperature.



In term of traceability, the Best Before Date is used as a product identification. If a recall is triggered on the products with suspicious BBD, all the products having that specific BBD are recalled even though they are from different batches. This is to make sure that they recall everything that can potentially cause risk.