Saara Ojanen

Food waste from organic produce at Company x

Author Title Number of Pages Date	Saara Ojanen Food waste from organic produce at Company x 56 pages + 1 appendix (removed for confidentiality reasons) 26 October 2017
Degree	Bachelor of Business Administration
Degree Programme	International Business and Logistics
Specialisation option	International Business and Logistics
Instructor	Marko Korkeakoski, Senior Lecturer

This study involves the subjects of the food waste, organic produce and the fresh produce industry. Food waste is a topic that deserves everyone's attention. Food is a human necessity but the sources of it are limited. Much of the produce that is grown for food ends up lost along the supply chain. The measures we take today greatly affect the food supplies of future generations. Should we choose to cut down in food waste, we would need to take various measures that concern the suppliers, wholesalers, retailers, decisions makers and consumers alike. However, the matter is not straightforward and just a question of attitude as even defining food waste proves challenging. This thesis project concentrated on organic produce wasted at Company x and the aim was to find out the reasons behind the waste and possible prevention methods for it. The study considered the company records from the years 2015 to 2017, and staff interviews as well as empirical research of the industry in general to establish a wholesome picture of the situation.

The key findings of this project concern the major organic waste product groups at Company x, the recording of food waste at the company and inventory management methods. The records showed that although the waste of all produce doubled from the year 2015 to 2016, the share of the organic produce stayed the same. In both years, 14% of the total waste was from organic produce (in comparison to conventional) but only 11% of profits were from organics. Therefore, waste from organics is slightly more than profits from them. The reason is likely a low turnover in combination with short shelf-life and not the organic label intrinsically.

The project also found that regarding the produce discarded after arrival, half of the waste is discarded for reasons such as pre-order product cancellations, best-before dates and

take-back agreements, which are mostly avoidable. A new Anomaly table for recording the reason, parties and quantities of produce wasted after arrival was suggested as well as inventory management methods based on supply chain wide transparency and co-operation.

Keywords	Food Waste, Organic produce, Date Labelling, Take Back Agreement, RFID, Ethylene, KPI

Contents

Helsinki
Metropolia
University of Applied Sciences

Appendix
Appendix 1. Removed for confidentiality reasons

List of Figures

List of Tables

1 Introduction

Roughly a third of the food that is produced for human consumption, is wasted or lost during the supply chain. When converted into calories, global losses represent approximately 24% of all food produced (FAO, 2011). On Earth, we can grow every year a finite amount of food. When Europeans and Americans buy around 25% more food that they can eat, they are taking up the land which could be used to satisfy demand for other agricultural products (Stuart, 2009). Every kilo of produced food, whether wasted or consumed, requires resources like water, fertilizer, pesticides, seeds, fuels and land to grow it. Food waste thrown to landfills produces CO_2 and methane when breaking down and therefore speeds up the global warming. Growing food that never gets eaten is unsustainable and calls for immediate measures.

In addition to being an ethical issue, wasted food is also unprofitable for business. Currently, the wasted produce represents a significant amount of Company x's turnover. Cutting produce waste would not only cut costs but it would also increase the company's profits. In comparison to the amount of organic food sold at Company x, the waste from organic produce represent a larger portion of the waste than waste from conventional, non-organic produce. In Finland, the sale of organic food and drinks increased by 14% in 2016 (Proluomu, 2017). As the demand increases, it is important to find the optimal storage and procurement solutions for organic produce to keep the waste under control. Fresh produce losses relate to the physiology of the fresh produce type, and the efficacy and appropriateness of the control systems applied throughout the supply chain. Many factors, such as temperature and ethylene management, time of harvest, pre-cooling and packaging, to name a few, are known to affect the post- harvest life of many fresh produce types and therefore, if not managed appropriately, will increase the risk of loss (WRAP, 2011).

The food waste issue calls for actions from every stake holder, including the decision makers, producers, wholesalers, retailers and consumers. In industrialized countries, more than 40% of losses happen at retail and consumer levels (FAO, 2011). In Finland, wholesalers and supermarkets waste around 65 to 75 million kilograms, or 14kg of products per every Finnish citizen per year (Silvennoinen, Koivupuro, Katajajuuri, Jalkanen, Reinikainen, 2010).

This thesis introduces the background and functions of Company x and maps out the definitions and reasons for waste from organic produce. A thorough examination of different product groups was performed as well as staff interviews, and a literary review to unveil the different reasons behind the waste at Company x. Based on these findings, a list of suggestions are given relating to transparency, monitoring and an overall management of waste from fresh produce at Company x.

2 Defining food waste and organic produce

In order to execute the research, clear boundaries had to be implemented. As the study concerned organic produce, the difference between organic and conventional produced was researched and described. The definition of waste also needed clarifying as it is a crucial factor, not only in the study, but in the overall subject of food waste, and it illuminates how subjective the term is.

2.1 Food waste

It is not easy to define food waste. There are several definitions for waste in general, and equally many definitions of food waste exist. Although waste occurs all along the food supply chain, most often food waste is considered the food that is made or grown for human consumption. Food waste includes such items as raw and cooked food as well the food discarded in the process of manufacturing, distribution, retail and food service activities (Segrè and Gaiani, 2012). Therefore, materials such as vegetable peelings, meat trimmings and spoiled or excess ingredients are also included in the broad definition of food waste.

In the USA, that wastes about 63 million tons of food a year (ReFed, 2016), the United States Environmental Protection Agency (EPA) has published a food recovery hierarchy - a top down triangle (Figure 1), that suggests how much weight should be put to each stage to prevent food waste. The top levels of the triangle are found to be the best ways to prevent and divert food waste because they create the most benefits for the environment, society and the economy. The EPA defines food waste as 'uneaten food and food preparation wastes from residences and commercial establishments such as grocery

stores, restaurants, and produce stands, institutional cafeterias and kitchens, and industrial sources like employee lunchrooms (EPA, 2016).

Figure 1: EPA's food recovery hierarchy (EPA, 2016)

It must be taken into consideration, that what is considered as food in some part of the world might be waste elsewhere, just as surplus in one stage of the supply chain could be used as a source in another stage. Cultural variations exist in what is considered garbage and what is food. Segrè and Gaiani (2012), have categorised food waste to edible and avoidable food waste and inedible and unavoidable food waste (Table 1). In other words, Segrè and Gaiani call food waste wholesome edible material intended for human consumption, arising at any point in the food supply chain that is instead discarded, lost, degraded or consumed by pests (Segrè and Gaiani, 2012). The word 'intended' plays a key role in this definition as it implies that the food was grown, manufactured or prepared for the purpose to be eaten but never ended up filling that goal.

Edible	
Avoidable food waste	Food that is thrown away that was edible (bread slices, apples, meat)
Possible avoidable food waste	Food that some eat and others do not (potato skins)
Inedible	
Unavoidable food waste	Waste arising from food preparation that is not edible (bones, egg shells, pineapple skin)

Table 1: Defining waste: edible and inedible food waste (Segrè and Gaiani, 2012)

According to some critics, the important part of food waste to focus on is the part that can be recovered and turned into something else or offered to someone in need. This recoverable food waste symbolizes the developed countries' consumerist lifestyle, which has grown used to discarding products not meeting strict quality standards, and wasting surpluses left over from catering and home cooking, and unsold products running out of shelf-life due to a miscommunication between supply and demand. Some of these items are illustrated in the table 2.

Food recoverable for human consumption
Edible crops remaining in farmers' fields after harvest
Produce rejected because of market 'cosmetics' (blemishes, misshapen, etc.)
Surplus perishable food from restaurants, cafeterias, caterers, grocery stores and other food service establishments
Packaged food from grocery stores, including overstocked items, dented cans, and seasonal items
Unsold fresh produce from wholesalers and farmers' markets

Table 2: Food recoverable for human consumption (Segrè and Gaiani, 2012)

Overall, the definition of food waste can vary in many ways including, but not limited to: what food waste consists of, how food waste is produced and what it is generated by. Waste can also be measured by economic value, mass (kilos), units like pallets or boxes, or nutritional value. In this study, we measure the economic value of the wasted produce. To sum this up, it is thus clear that there is not a single and commonly agreed definition of food waste.

2.2 Organic produce

Organic produce stems from organic farming, that follows the objectives and principles of producing food without the use of pesticides, synthetic fertilizers, sewage sludge, genetically modified organisms, or ionizing radiation. Organic production respects natural, sustainable cultivation systems and cycles. Natural fertilizers such as manure, compost, bone meal, and rock minerals are used for maintaining soil fertility. Weeds are controlled by mechanical methods, rather than through the use of herbicides (WSU, 2017a). The

production is controlled by a set of strict rules aimed at respecting the environment and animals (Organic Community, 2017). The European Union regulates organic food production and processing within the EU and organic goods imported from other countries.

The two primary concerns in handling organic fruit are maintaining the identity of organic fruit and preventing contamination with post-harvest chemicals. Conventional, non-organic produce is treated with waxes, preservatives and chemicals to make it more resilient. As organic fruit and vegetables are not treated to the same degree that conventional fruit and vegetables are, they may spoil faster. A study conducted by Sani-Pure Food Laboratories found that organic broccoli and lettuce had much higher levels of bacteria than conventional produce. This is not harmful bacteria, but it is bacteria that will spoil the produce much quicker (Tiersky, 2010). However, the use or quality of chemicals during growth are not the only factors affecting the fruit or vegetable shelf-life but the production, handling, storage and delivery of the produce all play a role. Even for the storage of conventional crops it is recognised that post-harvest handling has a greater influence on the outcome of storage than the use of post-harvest pesticides (Bevan, Firth and Neicho, 1997). Also, it must be noted that organic fruit that goes to the wholesale market as opposed to direct to the supermarket has a longer supply chain.

According to the study 'Tailoring organic apples by cultivar selection, production system, and post-harvest treatment to improve quality and storage life', post-harvest treatment of fruit with hot water (46 °C for 120 seconds) decreased fungal decay during storage in two varieties, whereas spraying the fruit with ten percent ethanol decreased fungal decay in all examined varieties. The study also found that optimization of storage conditions with controlled atmosphere (CA) and ultra-low oxygen (ULO) maintained fruit quality and reduced the amount of fungal decay (Tahir and Nybom, 2013). ULO type storage is becoming increasingly popular because it preserves the quality of fruit for a longer period. However, a successful application of this method requires optimisation of storage conditions with the most suitable gas mixtures for each fruit variety, as well as their length of storage and other parameters (Tahir and Nybom, 2013).

Respiration is a metabolic process concerned with storage, where carbohydrates are broken down by oxygen to produce carbon dioxide, water and heat. For successful storage, the process of respiration needs to be slowed down as much as possible without killing the produce. Respiration can be slowed down by reducing levels of oxygen and

increasing levels of carbon dioxide in the storage atmosphere. When produce is enclosed by any method, even in a sack or simple clamp, the produce itself respires. This increases the concentrations of carbon dioxide and decreases the concentration of oxygen within the store atmosphere. Controlled atmosphere storage works on this principle but the levels of these gases are regulated very carefully according to a variety (Bevan et al., 1997). Fruit and vegetables require oxygen to produce the ripening hormone ethylene. In storage systems where oxygen is maintained as low as possible (ULO), the produce can hold its condition because ethylene is controlled. However, produce stored at these low oxygen levels are at risk of anaerobic respiration, which causes skin discolouration, internal breakdown and 'off aromas' due to fermentation (Tahir and Nybom, 2013). The CA storage also tends to shorten the final part of the supply chain, as once the oxygen-deprived produce is released from the CA, the metabolic process picks up again and causes the produce to spoil faster. An example of this is the Chiquita's To Go bananas (Interviewee D, 2017). Therefore, it would be ideal to find the optimal storage solution for each fruit variety, but in the current storage facility at Company x this is simply not possible due to the high turn-over of produce stock and the great amount of varieties. The organic produce is not stored in its own room but amongst the conventional produce.

Of course, produce spoilage in transport and on the shelf is natural since decay processes begin as soon as the produce is harvested. Despite of this issue being a key component in the life-cycle of organic produce, very few comparative studies have focused on postharvest aspects, and the scientific basis of the possible differences between organically- and conventionally-managed produce is still debated (Tahir and Nybom, 2013).

3   The research question

My mission for the thesis was to find out what proportion of the Company x waste originates from organic produce and to investigate ways to reduce it. This task required careful analysis of the accounts where the waste is recorded, all the way down to the product level. Any exceptions and patterns in the records were followed to get a full picture of the numbers. These results were then compared to the Anomaly table from the quality department to find similarities. The objective was to see if organic produce had more pre-existing quality issues than conventional produce. A new Anomaly table was introduced to gather more information on produce discarded after arrival. The quality inspectors, and organic produce buyers were also interviewed.

The research question of the study was:

What are the causes and possible prevention methods for waste from organic produce at Company x?

The purpose of this study was to find out if waste at Company x can be traced down to certain products, producers, storage conditions or perhaps procurement conduct. In this report the results from the collected data, interviews, observations and subject literature have been analysed and suggestions for the future are given. The intention of myself, the researcher has been to help the company's decision makers, as well as the buyers and sellers alike by shedding light on the food waste topic.

3.1   The methodology of the research

Since the research topic concerns the records of Company x, I decided to execute multiple research methods. To back up the thesis, the background of the organic produce harvest and storage requirements researched from literary sources. I also implemented a new Anomaly table research for post-arrival waste that was filled in by the quality inspectors. The quantitative and qualitative data from this table was a source of primary research to produce some new knowledge on the subject. The quantitative research method was also applied for analysing the 'waste customer' accounts at Company x from the years 2015, 2016 and 2017. The product groups, individual products and months with the biggest amounts of waste were analysed and compared to the gross profit from different product groups. The primary qualitative data was collected by interviewing the quality inspectors as well as organic produce buyers at Company x.

3.2   Challenges and limitations

The research revealed that several significant causes of food waste are beyond the control of managers across the supply network. Factors such as weather changes, the natural variability of food products and seasonal effects on supply and demand are exogenous factors. Although these factors are important for understanding the origin of food or produce waste, the focus of this research is on those factors that are related to the supply network and those that can be influenced by management practices.

4   Company x

Company x is a fruit and vegetable wholesaler that trades conventional produce as well as local and imported organic produce. The organic produce includes fruit, vegetables, eggs, sauerkraut and a cabbage and carrot drink. Company x receives both packaged and loose organic produce in appropriately labelled boxes. Company x also has a packaging facility for organic fruit and vegetables. The business of Company x is purchasing, storage, packaging and distribution of fruit and vegetables, as well as importing of fruit and vegetables from outside of EU. The company has outsourced all the transport of produce. The customers are around 650 food wholesalers and retail sellers. Company x has offices in Vantaa, Lieto and in Tampere. The imported produce as well as most of the local produce is received primarily in Vantaa distribution centre, where the produce is inspected. The Vantaa distribution centre expands over 7400 m^2.

Over the course of five decades the company has grown from a small, man with a van - concept to one of the biggest independent fresh produce supplier in Finland.
The Finnish grocery retailing industry is one of the most concentrated in EU. The two biggest companies, S-group and Kesko, control over 83% of the grocery markets (PTY, 2016). The dominating duopoly also have their own wholesale warehouses and transport for the grocery stores. Small, individual wholesale companies cannot compete with economies of scale against Kesko and S-group. In order to stay in business and succeed, they must find other competitive advantages. Company x provides one of the most extensive selections of organic produce in Finland, as well as many exotic products. The long-lasting relationships with trusted and certified producers and top quality products have won Company x hundreds of loyal customers.
Company x has over 2000 different products of which 500 to 600 are active products. The reason for a large quantity of products is that the same product can be sold in different package sizes (Company x, 2017). Due to confidentiality reasons the company preferred to be addressed as Company x. The names of the company employees interviewed for the thesis are also withheld.

4.1   Food waste at Company x

As established in chapter 2.1, food waste can be defined in many ways. In this study, we measure food waste as economic loss of wasted produce. Produce wasted at Company

x does not only mean that the product itself is discarded and the money paid for it is lost but the wasted produce also causes a loss of income as it is a lost sale. In addition, the waste causes extra work for the quality inspectors and warehouse workers as they must sort through the produce to pick out, count and weight up the damaged, old or mouldy items. This is costing the company in working hours. Finally, the wasted produce is put into a trash compactor and once the compactor fills up, a waste removal company comes to empty it. This is also an expense for Company x. Therefore, the definition of waste at Company x is the loss caused by a combination of wasted produce, lost income, extra work and the payment made for the trash compactor (Figure 2).
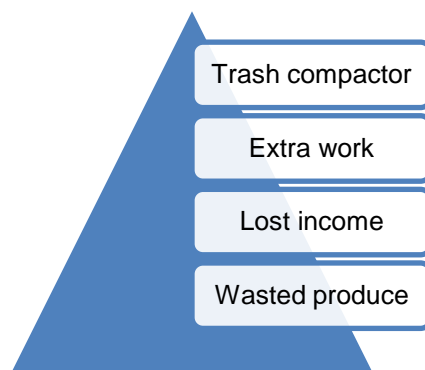
Figure 2: Different factors contributing to cost of waste at Company x.

The produce can be wasted during the transport to Company x, on arrival, during storage time, during transport to a customer or when refused by a customer. Most of the waste at Company x is caused during storage time but a considerable amount is wasted because customer returns, as discussed in chapter 7.3.

In this study, the waste is separated into seven different categories to help with analysing the waste. The waste categories are the following: pre-ordered products; dated products; products refused by customer; old products and products in poor shape (including dried out, mashed up, frostbitten and broken products); mouldy products; custom's samples; and other causes. The categories are discussed further in chapter 7.1.3.

At Company x, the products that do not achieve their intended market outlet because, for example, they are running out of shelf-life or have been returned by their intended customer, can often be sold in secondary markets (Figure 3). This produce is marked down for sale. These products that are past their prime are first offered to customers that sell at farmer's markets. The produce sold to the farmer´s markets are often sold at a

fraction of the market price, just enough to cover the purchasing costs. Although it reflects an efficient use of the product, because of being channelled into its next best market rather than being disposed of, this type of waste can represent a significant economic loss to business. Companies operating in food supply chain can also choose to distribute this close-to-expiry produce within their organization by setting up a dedicated area stocked with "free to take" products available to their employees. This practice is also in use at Company x where the produce past its prime is on offer for the company staff during a bimonthly food distribution day. Some of the produce is also given for free to non-profit organizations that assist the poor. These aid organizations serve food to people with insecure residency status or other people in need. Produce may also be donated to farm animals but it requires registrations with the Finnish Food Safety Authority as animal feed supplier, and the company would therefore be subject to The Feed Act (No 86/2008) that regulates manufacturing, transport, circulation, use, trade, storage and import and export of feeds in Finland (Evira, 2017).

This chapter shows that waste at Company x is not always waste per se as represented by the different factors contributing to waste, but also it shows that produce is not always wasted and turned into garbage but quite often it is successfully redistributed.
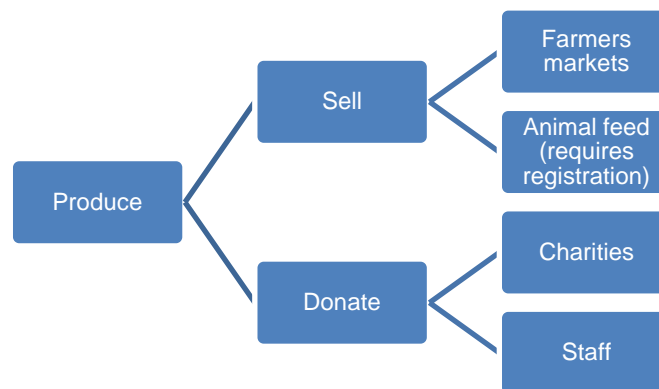
Figure 3: Possible redistribution channels of produce past its prime at Company x

Although waste prevention and reduction should be the key focuses of any business, it is a reality that every business creates waste, particularly the food industry. It is not possible to run a food wholesale business without waste, as the products are perishable, the supply chains often long and demand unknown. Should Company x have a zero-waste tolerance and buy only products to order and none to the warehouse storage to wait for customer orders, it would likely go out of business as the customers would stop calling in and ordering. The problem is that the customers of wholesale companies often find it

hard to predict their sales, so pre-ordering products is as difficult for them as it is for the wholesalers (Interviewee A, 2017). A substantial portion of Company x turnover comes from these storage sales and they help the business to grow.

A good example of the problem of measuring waste against costs and profitability is the case study performed by a postdoctoral researcher Mattias Eriksson and colleagues from the Swedish University of Agricultural Sciences (SLU), who used three years of data on cheese, dairy, deli and meat products waste from six Swedish supermarkets. This waste data was used together with data on microbiological growth on food at different temperatures and compared with the cold storage energy requirements. The study found that when the storage temperature was lowered, the food waste was found to be reduced for all products. This measure not only reduced waste but it gave increasing economical savings and greenhouse gas emission reductions for meat products. However, for the deli products the net savings were close to zero, while for dairy and cheese products there were net losses, since the costs of reducing storage temperature exceeded the potential savings. Turns out it costs so much more in electricity to reduce the storage temperature. Therefore, it was concluded that reducing storage temperature has the potential to reduce waste, but at a total net cost (Eriksson, Strid, & Hansson, 2016).

Nevertheless, waste reduction and prevention are important measures at Company x as they have the direct benefit of growing the profit. Also, there has been pressure from the part of the company owners to reduce waste (Interviewee B, 2017). This should be done in a way that does not compromise the customer sales and thereby cause loss of profit or some other forms of expenses. Whereas data collection and improved forecasting practices can help to reduce forecast errors, it must be recognised that uncertainty will continue to exist in the wholesaler industry and that forecast errors cannot fully be eliminated.

4.2   Receiving, storage and deliveries of organic produce

At Company x, the quality inspector is responsible for the arrival inspection and quality inspection of the fruit and vegetables, and hygiene training of the staff working in the warehouse. The arrival inspection includes the inspection of labelling and stickers, the brand, colour, size, quality, amount and temperature of the product. The imported produce arrives to Company x in a temperature controlled vehicles and containers. The local produce arrives primarily by transport organized by the producer (Company x, 2017).

The containers arriving to Company x from outside of EU are opened for the first time on arrival to Company x. Outside of EU, Company x only imports organic produce from Argentina and New-Zealand. The produce imported from these two countries does not require a separate import permit as their rules on organic production and control are equivalent to the EU's. For all other non-EU countries, importers can have their organic products certified for import into the EU by independent private control bodies approved by the European Commission (European Commission, 2017).

Primarily the growers that deliver organic produce to Company x only grow organic products. All the products have lot numbers that can be traced back to the farmers' fields. If a product is missing a lot number, Company x gives the product the lot number according to the arrival day and the lot purchasing date. If the box or the packaging labels are conflicting, the lot is taken aside. These products are then sold as conventional products and not organic (Company x, 2017).

After arrival inspection, the organic produce is stored in dedicated locations in two different storage halls. In the first storage hall, the room temperature is 3 degrees Celsius and in the second one it is 9 degrees Celsius. The produce is in an optimal room regarding the storage temperature and ethylene sensitivity of each variety. Organic bananas are stored and ripened in their own boxes and own pallets in the chambers. The pickers have been trained to understand the importance of storing regular and organic produce separate from each other. However, during an inspection in November 2016 it was noticed that the pickers knowledge of correct organic labelling was inadequate. Therefore, additional instructions regarding organic labelling were added to the instruction manual and a copy was handed to the pickers to read. The pickers are yet to be tested to see if their knowledge has increased (Company x, 2017).

4.3 The recording of food waste

During the arrival inspection, if a problem is noticed with the labelling, stickers, brand, colour, size, quality, amount or temperature of the product, then the product is either discarded or stored as a proviso [1]product and the producer is notified about the product's condition. If the product is mouldy, squashed, old, soft or has spots on it or a problem

---

[1] Proviso: An article or clause (as in a statute or contract) that introduces a condition (Merriam-Webster, 2017).

alike, it is discarded straight away and the quality inspector records this both in the 'Anomaly table' and in the data base under a specific 'waste customer' account. The Anomaly table also has the amount of the produce and the reason for disposal recorded in it. This Anomaly table will be used during the project to compare how many times organic produce appears on it and for what reasons, and also to see how many times a proviso product leads to waste.

However, once the produce is put on shelves, and if pickers or quality inspectors find products that require discarding, then only the amount of the product is recorded in the waste customer account, but no record is made of the reason behind the rejection. The Anomaly table is used only for arriving produce. Therefore, I would suggest implementing a permanent Anomaly table for pickers and quality inspectors, where the reason for wasting the produce would be recorded. Then it would be easy to look back to the previous years and see what the reasons were for the discarding. The company is already taking steps towards a permanent record by planning to implement a Muddy Boots Software on quality control, that would help to report on the performance of the suppliers and customers alike (Interviewee D, 2017).

Sometimes the quality of the produce delivered to the customers does not please them. In that case the customers make a claim by informing Company x by emailing or calling. Often, a picture is provided as evidence of the claimed product. In most cases Company x returns to the store to pick up the claimed produce and takes them back to their warehouse. The quality inspector records the returned and claimed produce to the data base together with the buyer responsible for purchasing the item. If the claimed produce is a considerable amount, i.e. a full pallet, this information is then passed on to the buyer, who then contacts the producer. This process is not automated as the information is emailed to the producer or supplier. The quality inspector also records the possible food waste items on arrival and when preparing pallets for a delivery to customers. The waste from packaged produce is followed by monitoring the difference between bought and sold produce at the packaging facility account. The sellers of the produce are recording the information about possible customer claims and compensation to the accounts in the data base. The quality inspection receives and signs off the returned items (Company x, 2017).

4.4 Warehouse Management System

A warehouse management system (WMS) is a software that helps with the day to day operations of the warehouse. For example, it can control the movement and storage of materials within a warehouse and process the associated transactions, including shipping, receiving, putaway and picking. An efficient WMS can help a company to increase profitability by faster and timelier movement of products through the supply chain with minimum handling of goods and maximum throughput of orders. The voice-directed product picking increases the efficiency rate of goods collectors' output and minimize errors in delivered goods. (Aptean, 2017).

The WMS used by Company x is IMI Aptean. This system is used for monitoring the pallets and boxes as the Company must be able to trace every box and pallet all the way back to its origin. IMI has information about the specific storage temperature for each product group. The system uses this information when suggesting a specific picking and storage location for products. The web-based slotting solution determines the optimal warehouse location for each products based on volume, dimensions, weight, and location attributes. With IMI, there is a possibility for using an automated process for stock rotation combined with goods aging reports to help minimize stock obsolescence. The method used in Company x is FIFO (First In, First Out) storage management. However, at the moment Company x does not use the program for products with an expiry date as the system is designed so that it does not call for the products on the day of expiry and therefore the products would be left in the shelf. For this reason, the sorting of products with expiry date is done manually (Interviewee B, 2017).

Ethylene is a ripening hormone which is triggered at maturity in fruit. Some WMS have integrated ethylene control systems. The use of ethylene for ripening is a common practice in fruit and vegetable warehouses and commercial ripening chambers. While ethylene is useful for ripening of many fruit it has also proved to be harmful for many fruits, as it causes premature ripening and rotting of the fruit and vegetables. At Company x, the ethylene levels are controlled only at the banana ripening chambers, because the gas itself is a key component in the ripening process. Elsewhere in the warehouse, in the standard storage rooms, there are no ethylene sensors or filters as these are very expensive and require specifically trained personnel to use them. The banana chambers are controlled by their own system as well as the ethylene level at the banana chambers (Interviewee B, 2017).
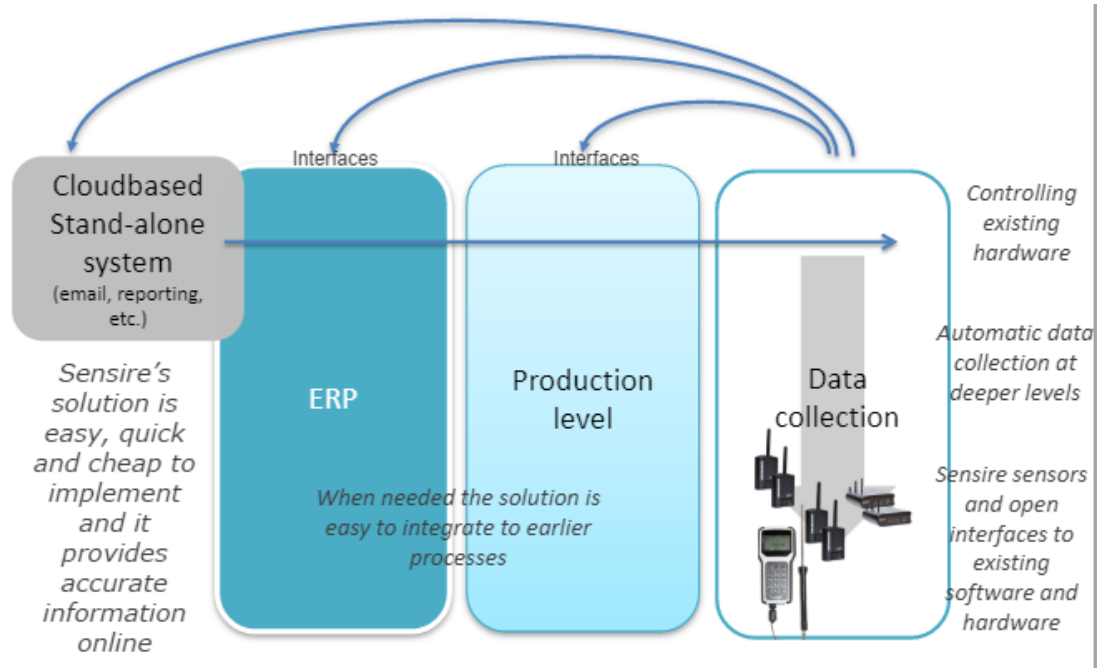
Figure 4: Automatic temperature monitoring Sensire TempNet (Sensire, 2017)

5 Factors affecting waste

As previously mentioned, organic produce farming differs from the farming of conventional produce. Likewise, the pre-harvest factors such as harvest loss and damage to harvest, climatic conditions, access to modern technology, greatly affect the outcome of the produce. While much of this is at the fate of the "Mother Nature", many preharvest management factors can affect the afterlife of an organic produce, for example excessive irrigation, high plant density, high level of soil nitrogen, improper manure use and contaminated irrigation water, as well as harvesting produce when dry (Mokkila, Sariola and Hagg, 1999). In addition, factors like pre-cooling, storage temperature, transport and procurement, that are not only related to organic but all produce, greatly affect the shelf-life of the produce.

5.1 Precooling produce

Whereas pre-harvest factors cannot always be influenced, the post-harvest factors are all subject to human control. Every postharvest step has an influence on the quality and shelf-life of the organic product. According to a study The key factors in the harvest and

postharvest treatments of strawberries (1999) by Mokkila et al., the most critical factor influencing postharvest quality is the temperature of the produce. The period from harvest to pre-cooling is critical, because this is when the fresh fruit and vegetables are at their 'field heat', in other words at highest temperature, and losing shelf-life at significantly accelerated rates. Field heat is the heat stored in produce standing in the field. Precooling is a process in which the field heat is removed from the produce rapidly after harvest. This process restricts the plant respiration and reduces the rate of biochemical and microbiological changes, consequently extending the shelf-life of the produce (Han et al., 2016). The most rapid cooling technique is vacuum cooling, where the field temperature drops to storage temperature in twenty minutes. The study by Mokkila et al., also found that cooled strawberries did not get damaged by transport vibration as much as uncooled strawberries. It is widely recognized now that pre-cooling as soon as possible after harvesting and storing produce at low temperature are essential for decelerating the respiration rate of fresh produce and that pre-cooling is the most important of the postharvest treatments (Mokkila et al., 1999; Han et al., 2016; Allais and Létang, 2009).

In addition to postharvest temperature management, a number of other postharvest treatments and management methods have been developed including various physical, chemical and gaseous treatments. The correct treatments applied with appropriate storage conditions has the best results regarding longevity (Mokkila et al., 1999).

5.2   The procurement process

The procurement of fruit and vegetables has a leading role in the waste management process. To understand the procurement process at Company x, it is necessary to find out how the procurement function is organized in the company, as well as about the company´s supplier selection and evaluation and the supplier management. The risk management and cost efficiency are also part of the procurement process.

Efficient fruit and vegetable procurement requires forecast planning and market responsiveness. The fruit and vegetable demand and supply environment is primarily driven by time-based crop production in desired quantity and cost for responsive and flexible supply (Dries, Germenji, Noev, and Swinnen, 2009). In Company x, the buyers and sellers must understand the specific characteristics of each fruit and vegetable and the general supply chain planning and coordination. Fruit and vegetable procurement does not only require a customer demand for a certain product but it also requires a buyer and supplier co-operation, and business sense. As most produce is seasonal, and the supply depends

on various factors like weather and crop quality, the wholesaler and supplier collaborations is vital. When there is ample supply to the foreseeable future, it is best to offer that product. Likewise, when the season of a product is coming to an end, it is best to know this weeks ahead. A great business acumen involves the ability to fulfil the customer's needs. In fruit and vegetable procurement this means offering the customers various new and exciting products and this way creating and modifying their needs (Interviewee D, 2017).

According to the organic produce buyers interviewed for this study, a part of the daily routine is to check how much produce is left in storage and how much must be ordered. The stock quantity is often checked many times a day. The ordering is done day by day and the buyers do not use any predictive software but their years of experience in the business. Some produce, like apples and pears have previously been ordered based on pre-determined amounts. This turned out to be an unsuccessful way of ordering as Company x was not able to sell all products and a lot of it went wasted. The buyers also have access to the previous years' records to aid with forecasting, use their own forecasting excel tables, and they follow the waste records closely, but at the moment no other KPI's regarding suppliers or produce is recorded (Interviewees A and C, 2017).

The locale produce buyer quite often shares our storage records with the producers. This act of transparency prevents waste as it helps the producers with their own forecasts and to determine their farming schedule. With the produce bought locally no long-term forecasts are required as the lead time is very short, sometimes only one day. As well, the procurement process for the local produce is very short as it usually includes only two to three people: the producer, sometimes the supplier and the buyer of Company x. The company uses trustworthy producers that they have a long track record of doing business with. What comes to new producers, it often helps to do a bit of networking and ask other partners around about these companies (Interviewees A and C, 2017).

The procurement of organic produce differs from the conventional in that a lot more thought is put into it as the produce is more expensive. The selection is carefully planned and seasons effect it a lot. Around 90% of the produce is bought to the storage (i.e. not pre-ordered products) and the stock is then sold to the clients (Interviewee A, 2017). The procurement of foreign organic produce is especially challenging as the price is higher than that of conventional produce and the turnover is smaller. In order to keep the transport costs down, the buyer usually plans the pallets around one major seasonal

product. Other organic produce is then bought in smaller quantities to fill up the pallets. According to the buyer, it is more efficient to buy smaller quantities of produce more often, than big amounts at a time as the produce does not necessarily last for long-term storage. The changing of seasons can be problematic as the last produce of the season is not often great quality and the produce must be sold out before expiring (Interviewee C, 2017).

Food trends and fads are hard to predict as there is no history for the trendy products. The procurement is also greatly affected by the weather at farm and at destination. Should the cold spring strike, like in 2017, the crops would simply not grow. In this situation, the prices went up as every company searched for alternative suppliers. Similarly, an unusually cold summer would have consequences as the consumers tend to purchase differently depending on the outside temperatures. Also, the seasonality of the produce itself sets limits as many products are not available all year around. Furthermore, the marketing campaigns, product launches, promotions and special occasions like Christmas and Easter affect the procurement significantly. Some bigger supermarket chains have their own seasonal campaign plans that they have shared with Company x. This pull method of procurement aids the company with their promotional planning. However, Company x would ideally use the push method of procurement and plan their campaigns with the suppliers. This way the supplier can offer the products that are available at good quantities and great quality (Interviewees A and C, 2017). Therefore, procurement is all about the having the right quantity, at right time, in right place, just as an effective supply and demand chain is often measured.

6   Challenges of the environment

Compared to products with a long shelf-life or stable demand, the fresh fruit and vegetables (FFV) are quite challenging to work with. The perishable nature of the produce and the emergence of contract farming and farmer cooperatives have developed the industry towards rapid production cycles and volatile demand (Dries et al., 2009). As previously established, the price, demand and supply of the produce are also affected by the weather conditions and that is why forecasts cannot be based on historical sales, but the procurement plans need constant revisions.

The supply chain planning and coordination environment of farmers, logistics, packaging, storing and distribution processes are very complex. The supply chains for short life-

cycle products like FFV must sustain competition due to the fast-changing customer de-
mand. According to an article in the International Journal of Supply Chain Management
by Professor Bahinipati, with the FFV supply chains which are characterized by the pro-
curement of quality fresh produce from a small number of farmer cooperatives and a
large number of small- and medium-capacity farmers, the major challenge is the accurate
and real-time information sharing. Professor Bahinipati finds that literature on the supply
chain planning for fresh produce emphasizes mostly the buyer-supplier collaboration,
whereas inter-enterprise collaboration would be required. Responsive and flexible supply
chains are essential in the volatile fresh produce market. As well, the integration aggre-
gates data from multiple sources, such as customers, retailers and farmers that can be
efficiently used for the benefit of every stakeholder (Figure 5) (Bahinipati, 2014).
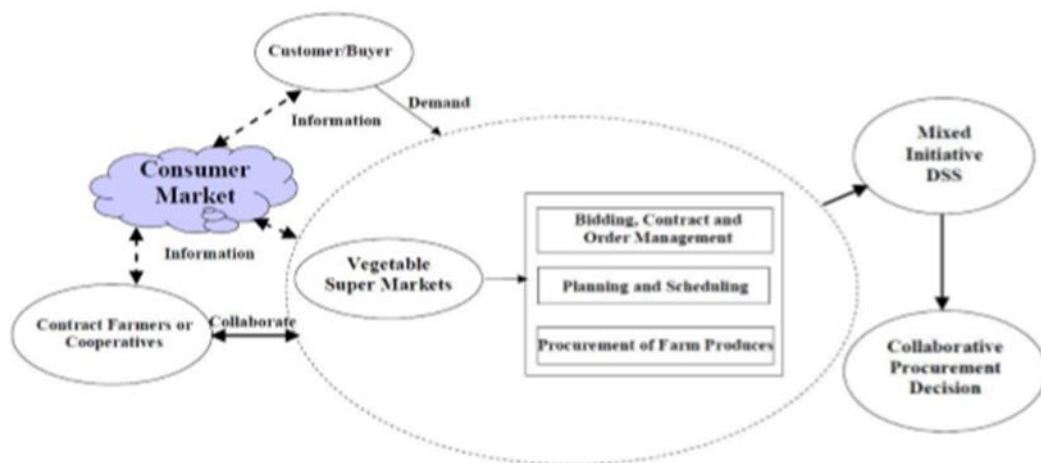
Figure 5: Dynamic fruit and vegetable supply chain (Bahinipati, 2014).

6.1 Competitors

During the research on Food Waste Volume and Composition in Finnish Food Chain by
Silvennoinen et al. (2012), it was estimated that the total food waste of Finnish wholesale
and retail business to be 65-75 million kilograms or 12 to 14 kg per every Finnish citizen
per year. The main product groups causing food waste in stores were fruit and vegeta-
bles, and bread. In order to build a good picture of the amount of waste being created at
Company x we should be able to compare it to that created by competitors. However,
this information is not easy to come by, as there is no clause in law binding the retailers
and wholesalers to report their quantities of waste. It is up to the companies themselves
to be open about it and fortunately many have made some statistics available in a yearly
Corporate Social Responsibility (CSR) report, available online.

6.1.1   S-Group

S-Group is the largest operator in grocery market field with a 45% share of the markets. According to a consumer panel by Nielsen Homescan, S-Group accounted for 59 per cent of consumers' organic product purchases last year, therefore making it the most popular organic product stores in Finland. The sales of organic produce grew by 20 % compared to the previous year and fruit and vegetables grew by 37% (S-Group, 2016). Loss is managed through systematic management of orders, deliveries, transports and inventories. In 2015, S-Group stores implemented a special tool to better monitor loss at the store and the causes of loss. In 2015, the ratio of food wastage to food sales was 1,67% in S-Group's grocery stores. The reported percentage also includes food items donated to charity through cooperation partners. In 2015, the total amount of loss gen-erated was 32,4 million kilograms (S-Group, 2016).

6.1.2   Kesko

Kesko Food manages the K-food store chains, which are K-Market, K-Supermarket and K-Citymarket. Kesko Food's subsidiary Kespro is a leading wholesaler in the Finnish HoReCa business. In 2016, organic products contributed to 1,6% to the sales of K-food stores but at some K-food stores, their share was as much as 6–7% of net sales. The selection of a K-food stores consists of the central warehouse products and items sourced by the store itself. The total organic selection of the K-Group includes 2,000 products (Kesko, 2016). Kesko has set a target to reduce their food waste by 10% from the 2013 level. By the end of 2016, K-food stores had reduced food waste by 3,5% from the starting point. According to Kesko's CSR report, this was achieved with the

> *help of electronic forecasting and order systems, efficient logistics, employee train-ing, reducing the prices of products approaching their best before dates and opti-mising packaging properties* (Kesko, 2016).

6.1.3   Wihuri Oy Aarnio

Wihuri Oy Aarnio operates Metrotukku, which is one of the biggest wholesaler chains in Finland. Metro claims to have 23% of the retail wholesale markets in Finland. Wihuri provides a full CSR report on their website were waste is separated in different catego-ries. The report mentions that waste from organic material grew from the previous year

due to an increased product variety and one major break down in a cool room that caused a lot of produce going to waste. According to the report, wasted food is a great concern to Wihuri and they have engaged to the United Nations sustainable development targets and are training their staff to become aware of the issue. Wihuri also uses Relex-procurement software and donates produce to charities (Wihuri, 2016).

Although a lot of information from these and other competitors is available to the public, the quantities of waste from organic produce are not published or quite possibly not even recorded. The quantities in kilograms of different categories of waste, i.e. biodegradable, mixed and hazardous is possible to find, but no specific explanations regarding the origin of waste is commonly not provided.

6.2 Government role

The topic of supermarket waste has been widely debated in the Finnish media over the last few years and a bill that would mandate supermarkets to donate unsold food instead disposing of it, has been discussed at the Finnish parliament in May 2016. Similar actions have taken place in Italy and France where in April 2015, the French policymakers released proposals for a national policy against food waste, including ideas for prevention, recovery and recycling. Then in February 2016 France became the first country in the world to made it illegal for supermarkets to throw away or to destroy unsold food, making them instead to donate it to charities and food banks (NRDC, 2015).

According to Juha Ketola, a former merchant at K-supermarkets who is currently running a food waste prevention consulting company, the French way of mandatory food donations would not solve the Finnish supermarket food waste problem. This is because as mandated by the Finnish Food Safety Authority EVIRA, it is illegal to distribute products past expiry dates, unless the products are frozen. Most of the unsold food products at supermarkets are at their last expiry date, which makes donating them the next day illegal. Mr Ketola suggests that the law would be changed so that it would still be possible to donate these expired products one day after expiry date (Ketola, 2016).

Many consumers want to make healthy and sustainable choices when choosing where and what to eat. However, it is not always easy for a consumer in a modern world to make these choices. Many consumers are not aware of the entire food chain, the various actors involved, and the moral implications associated with their decisions. The setting

in which people currently make their routine food choices is not guiding to more sustainable consumption patterns. The consumers play an important role in the transition towards a sustainable economy through making choices and promoting them further. For this they need sustainable policies and experiments. The study Transition towards Circular Economy in the Food System by Helsinki University suggested, that the pace of this transition is influenced by private consumers, as well as larger actors, such as the hospitality industry and municipal services (Jurgilevich et al., 2016). Consumers need more education about food, food chains, food waste effects on environment, sustainability, waste management and packaging. The sustainable consumption habits should be promoted through campaigns and educational programs. Nevertheless, awareness campaigns will not be enough to reach out to the entire population, and therefore it is necessary to address the "food environment" that people live in (Jurgilevich, Birge, Kentala-Lehtonen, Korhonen-Kurki, Pietikäinen, Saikku and Schösler, 2016). To this end, wholesalers, supermarkets, food service, and public catering need to be involved in efforts to, for example, promoting seasonal produce and advancing on the storage of fresh food items.

The European Union has awoken to face the food waste issue and many plans have been made. On the 7th of June 2016, the Members of the European Parliament (MEP) adopted a resolution, calling for fair and transparent trade relations among food producers, suppliers and distributors by guaranteeing a wider choice for consumers (Europarliament, 2016). The exact quantity of waste from farms is the biggest unknown of all waste statistics. One reason being that waste separated on the farm is often not legally classified as waste at all because farmers can plough it back into their fields and it does not need to be processed and treated in the same way as industrial waste (Stuart, 2009). The plan is now for the European Commission to come up with proposals to improve farmers' bargaining position as they believe that fair trading practices should also help to prevent overproduction and food waste (Europarliament, 2016).

Governments all over the world are now reflecting whether forcing retailers to declare their annual waste quantities and reveal their waste quantification methodologies could be a good way to help the reduction of food waste. Segre and Gaiani (2012) believe that the introduction of transparent annual mandatory food waste audits across all large food industries and the introduction of fiscally driven food waste reduction would see a huge and lasting reduction in food waste.

6.3   Transparency

The study Foodspill by the Finnish Agricultural Research Centre took place between the years 2010 and 2012. The aim of the project was to identify the volume and distribution of food waste in Finland. The research concentrated in households, food services, the retail sector and the food manufacture industry, one area at a time. This study was the first study of a kind in Finland and it was essential in shedding some light to the subject of food waste and to affirm previous small scale studies on the topic. The study established the total food waste of Finnish retail and wholesale sector to be between 65 and 75 million kilograms per year. However, this part of the research was exclusively carried out by interviewing the various parties associated. No weighing or measuring of the actual amount of waste was carried out and no statistical data used. We can presume from this that determining the actual amount and causes for waste in the food supply chain would require more auditing and data.

Food waste statistics are not commonly shared in public. The published food waste campaigner Tristram Stuart (2009) finds that retailers do not want to publish the data on how much they waste, as this is sensitive information regarding logistics. Stuart suggests that if it was mandatory for the retailers and wholesalers to publish their waste data, it would put all the companies on the same level. Then competitors could even learn from each other about how to reduce the impact of their waste. Mr Stuart also finds that accurate and transparent figures are needed to ensure that surplus food is properly redistributed through the right channels.

Transparency in data and supply chain are key issues of the food waste topic. According to the research by Agrifood Research Finland 'What can the Finnish food supply chain be proud of?', the main challenges of the food chain identified were traceability, transparency and consumer communication (Kotro, Jalkanen, Latvala, Kumpulainen, Järvinen, and Forsman-Hugg, 2011). The authors suggested a traceability system where the actions related to responsibility could be verified transparently. We can already see this today, for example in Atria meat and chicken packaging where the name of the producing farm is printed on the label.

Study on information sharing in fresh food supply chain by Kaipia, Dukovska-Popovska, and Loikkanen (2012), Creating sustainable fresh food supply chains through waste reduction, found that the performance of fresh food chain of milk, fish and poultry can be

improved by more efficient information sharing. Due to the short overall lifetime of these products, the time management becomes essential and the time needs to be shared between supply chain activities. Improving the performance in the supply chains requires focusing on multiple parallel issues in goods and information flow, including streamlined supply chain, the moving of order penetration point (OPP) as close to the end customer as possible, efficient forecasts, and the demand data available to all parties of the supply chain. Therefore, the study concluded that improving the sustainable performance requires changes in the whole supply chain and not only in the phase where the problems occur (Kaipia et al., 2012).

Another research Causes of waste across multi-tier supply networks: Cases in the UK food sector (Mena, Terry, Williams, and Ellram, 2012), also suggested that improved supply-chain wide transparency of demand information in the supply network versus a focus only on internal requirements can reduce food waste. According to this research, some suppliers, who participated in collaborative forecasting and monitoring sales with their clients found it to be very beneficial in terms of cut waste and costs. Investing resources into improving forecast accuracy and vertical integration were also found to have positive results. The research also revealed that companies' internal focus on maximizing profit and lack of transparency in managing promotions could lead to increased food waste. This was because promotions appeared to contribute to more unpredictable demand patterns which in turn made forecasting difficult. The research suggested using supply driven promotions which could cut the waste instead (Mena et al., 2012).

As we have seen in the aforementioned studies, there is demand for more transparency in the food industry both in the consumer and industry level. The transparency in waste statistics would help to draw an accurate picture of the amount and causes for waste, whereas the transparency in supply chain could help to reduce the waste. In addition, as pointed out in the fresh food supply chain study by Kaipia et al. (2012), all stakeholders of the supply chain would benefit from it.

7   Findings and suggestions

In the previous chapters I have described food and produce waste as well as the differences between organic and conventional produce. As FFV waste is a very complex subject, in this thesis project I only consider waste which has the largest economic value

and not the waste with the largest mass, the number of times appearing on the list or the greatest nutritional value. When planning the project, it was important to consider a goal that was feasible. Measuring the monetary value of waste seemed rational because of pre-existing framework.

Every product has an identification number. Some products have many ID-numbers, depending on the size of package and the country of origin. This way, an item such as 'asparagus' could have ten different product numbers. For this reason, instead of measuring the largest individual waste product by identification number, it was worth considering the total waste of all products named 'asparagus'. More so, all products are divided into product groups. These product groups were at the centre of the research. First the product groups with a recurring high waste were identified. Next the high-waste products within the groups were looked into. These products and product groups are named in this chapter.

7.1   Statistics regarding produce waste at Company x

The amount of produce waste at Company x doubled between the years 2015 and 2016. This was mainly due to a combination of quality issues with fruit, and new delivery methods and too big stock purchases. All in all, the amount of waste grew in nearly all product groups. Interestingly, although the amount of waste doubled, the share of the organic produce of total waste and gross profit, remained exactly the same: 14% of all waste was organic and 11% gross profit was from organic produce. Of the year 2017, only the first six months were included in this project and therefore the numbers are not comparable to the previous years' results. As Company x sells seasonal produce, many of the products have not come in season during the first half of the year. However, some conclusions, as presented below in figure 6, can be drawn from these statistics.
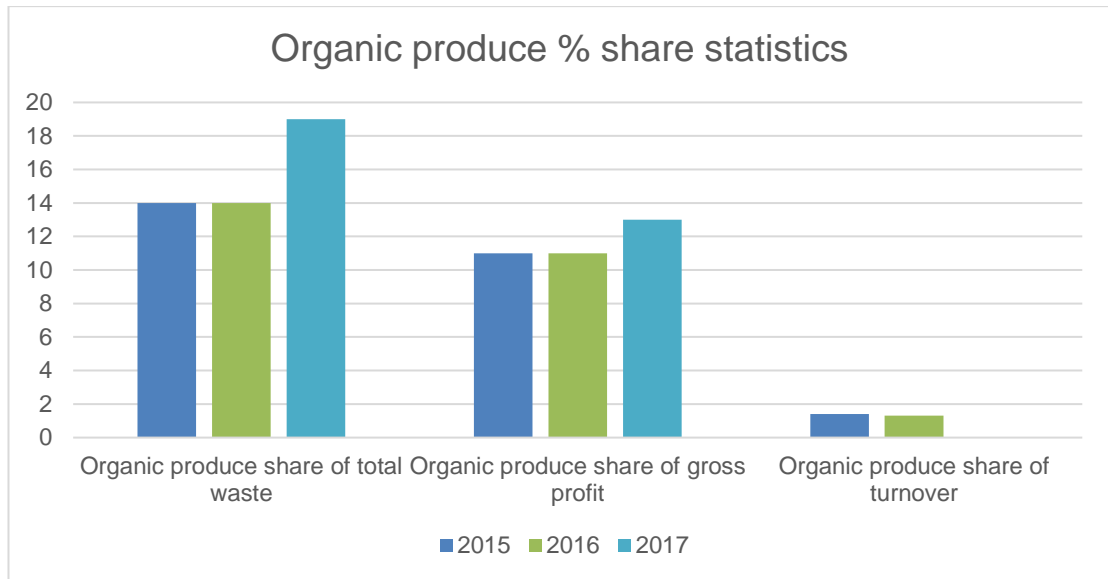
Figure 6: Organic produce share statistics 2015, 2016 and first half of 2017.

7.1.1 The major waste product groups

The statistics used for this thesis project were the accounts, were trash and gross profit accounts for each product group. The trash accounts are the accounts where disposed products are recorded, as well as the farmers' market account, as this is secondary market, and donation accounts. All these trash accounts consist of produce that did not reach its intended market. The total waste for each product group (i.e. bananas, oranges, mandarins, clementine etc.) was calculated. As well, the total for the organic produce in each waste product group was calculated. As an example, in 2016, of the total waste of product group pears, 29% were organic pears. Next, the gross profit for organic produce of each product group was calculated. This shows how big of a share did organic produce have in each product group. For example, in 2016, organic pears represented only 12% of the gross profit of the pears. This comparison shows that although organic pears represented a third of the waste in its own product group, they stood for only 12% of the gross profit. In general, looking at the statistics of 2015 and 2016, 14% of the total waste was from organic produce but only 11% of the profit was from organics. Therefore, waste from organics is slightly more than profits from them. In 2016, twice as many product groups (14) had more waste from organic produce than profits from organic produce (7). In 2015 this comparison was 50/50. It is difficult to look back now to see what the reasons were for the disposals. An anomaly table would help with explain it.

The following product groups have a high waste of organic produce in comparison with the gross profit of organic produce.

Bananas

The bananas had a tough year in 2016. The waste from bananas grew considerably from the beginning of year 2016 due to slow reaction to changing situations (Company x, 2017). This made bananas the ultimate top high waste product group in 2016 when bananas represented 36% of all waste. The share of waste from organic bananas also grew but only very little. In 2016, the share of waste from organic bananas was just 6%. That year, 88% wasted bananas ended up in the trash. From the remaining, half was donated and the rest was sold to the farmers' markets.

In 2017, one quality default with organic bananas caused a spike that created half of the waste of this product group. Due to this spike, the organic banana waste went up by 40%.

Avocados

In 2015, organic avocados were a top product. They represented 42% of the avocados gross profit but only 3% of the waste. However, in 2016 the waste grew to 38 % and gross profit dropped to 29%. In 2017, organic avocadoes are again making a lot more profit, with 29% share of the product group's profit and only 3% of the waste. It seems that the quality issues have been overcome and the procurement has been moderate.

Melons

In 2015, melons were an average product group. Organic melons represented 3% of gross profit and 1% of waste. Then in 2016, melons became the second biggest waste product group and third biggest organic waste group. Organic melons had a negative gross profit. The major part of the melons ended up wasted in summer between the months of May and August as this is the melon season. These were products like cantaloupe, mini watermelon and honey dew melon. Most of this waste is due to the fact that too much produce was bought and not enough sold. The melons were new products at the Company x, so there was a lack of track record on what to base the forecasting. As melons are summer season products, no organic melons were sold between January

and May 2017. Due to this reason we cannot make a comparison to the previous years with this product group.

Other vegetables

This product group includes a lot of different products, including zucchini, eggplant and asparagus. Although this was the third biggest organic waste group in 2016, the organic produce created more profit (33%) to its product group than waste (19%). This was alike in 2015. For the first half of 2017, the waste of organic produce is ten percent higher (33%) than the profit (23%).

Apples

Apples have been problematic. Both in 2015 and 2016, the waste from organic apples was greater than profit from organic apples. In 2015, 43% of the waste was from organic apples and 17 % of the gross profit. In 2016, 60% of the waste was from organic apples but only 20 % of the profit. Unfortunately, this trend seems to continue in 2017. So far this year, the waste from organics is at 65% and profit at 7%. No organic apples have appeared in the anomaly table and no great waste spikes have been identified but the apples have been disposed of regularly throughout the year. Still, it is possible that there have been indistinguishable quality issues with apples. Another reason would be that too big quantities have been bought in relation to demand, as happened in 2016 when ordered quantities were agreed ahead (Interviewee C, 2017). The turnover was too slow and large qualities perished in the storage and were sold to the farmers' markets.

Grapes

Besides apples, grapes are the second product group that has continuously had more waste than profit from organic produce. In 2015, the waste was 20% and gross profit only 6%. In 2016, the gap grew even more with 35% waste and 4% gross profit. Fortunately, around half of these grapes were sold to the farmers' markets. In 2017, more than half (53%) of the wasted grapes were organic. Grapes are problematic, because the waste is both constant all year around, and there are quality issues spikes that cause great amounts of waste. Grapes are not found in the anomaly table which means that there has not been visible problems on arrival. However, the quality inspectors agree

that grapes do not last long in the storage and they are used to checking, sorting and redistributing them to the farmers' markets. To this end, the turnover of grapes must speed up to avoid waste.

Berries

What comes to all waste, berries are one of the biggest waste product groups. However, organic berries only represent around 10% of this, although this is more than the profits from the organic berries, which stands for only 1%. Cherries and bush blueberries were the biggest organic waste products in this group. In 2015, a great amount of strawberries were disposed of in February. These berries were known to have a quality issue on arrival. Hardly any berries were redistributed to farmers' market that year. In 2016, a great amount of organic cherries were disposed of and redistributed in June. These cherries can also be found in the Anomaly table. These two examples show that when the turnover is small, large waste spikes make a big difference in the profit of the organic product. This is because the price of the organic produce is greater than conventional, so the waste becomes costly.

Exotic fruit

This product includes fruit like maracuja, pawpaw, aloe vera, mango, turmeric, almond and hazelnut. This product group is a high waste group. Although organic produce causes quarter of the waste, it brings in 40% of the profit. Therefore, this is a very strong organic product group. So far in 2017, the waste and profit from organics are somewhat even.

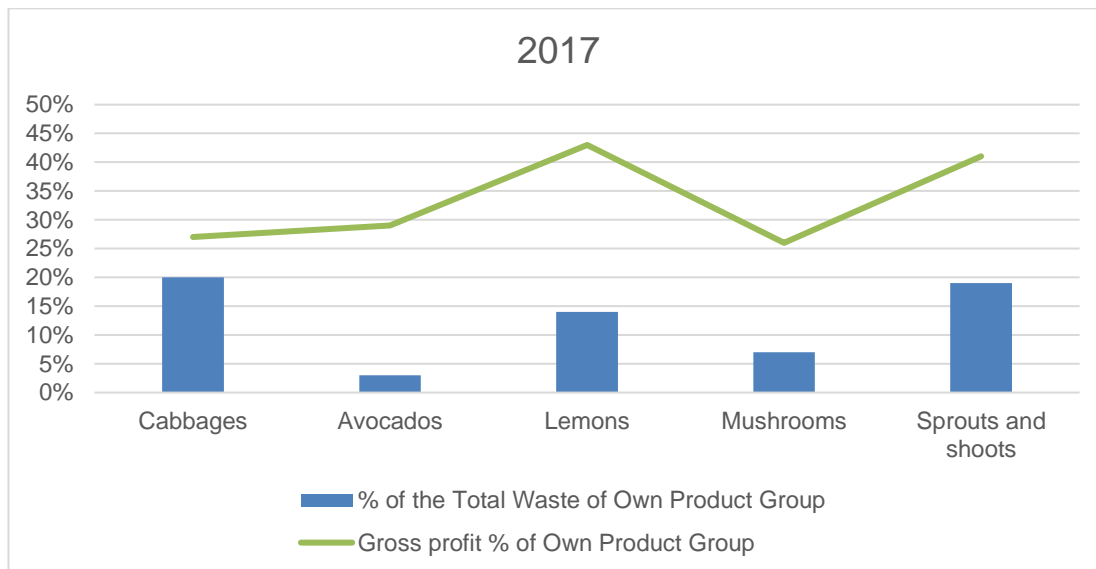Figure 7: Organic products in 2015, 2016 and first half of 2017, which created more profit than waste in own product group:
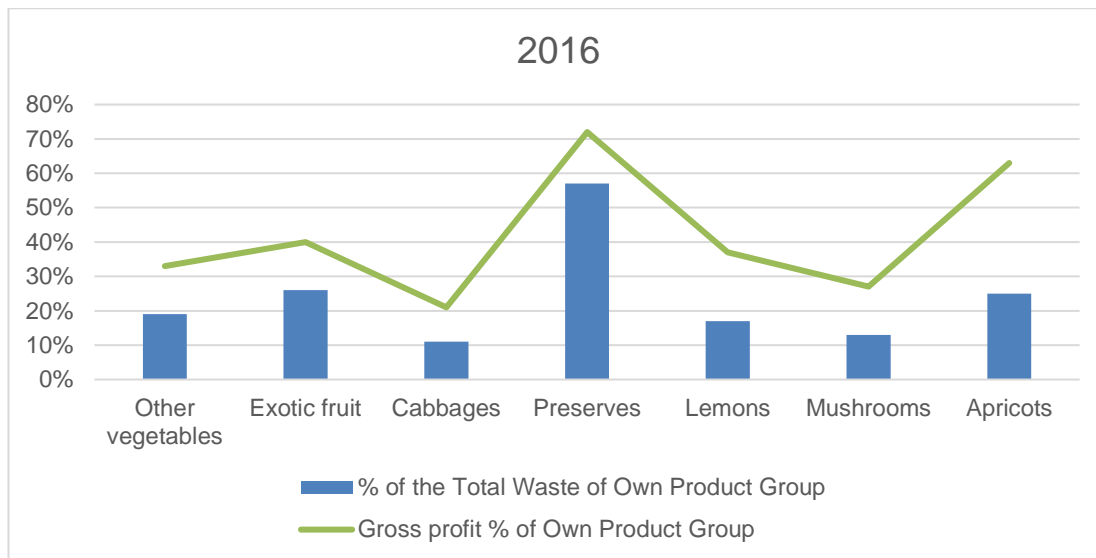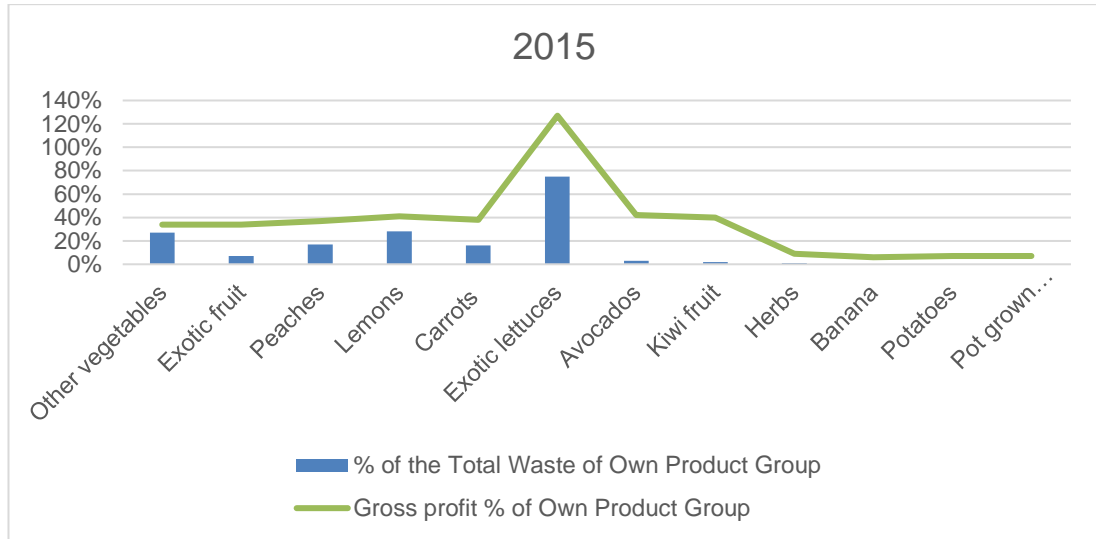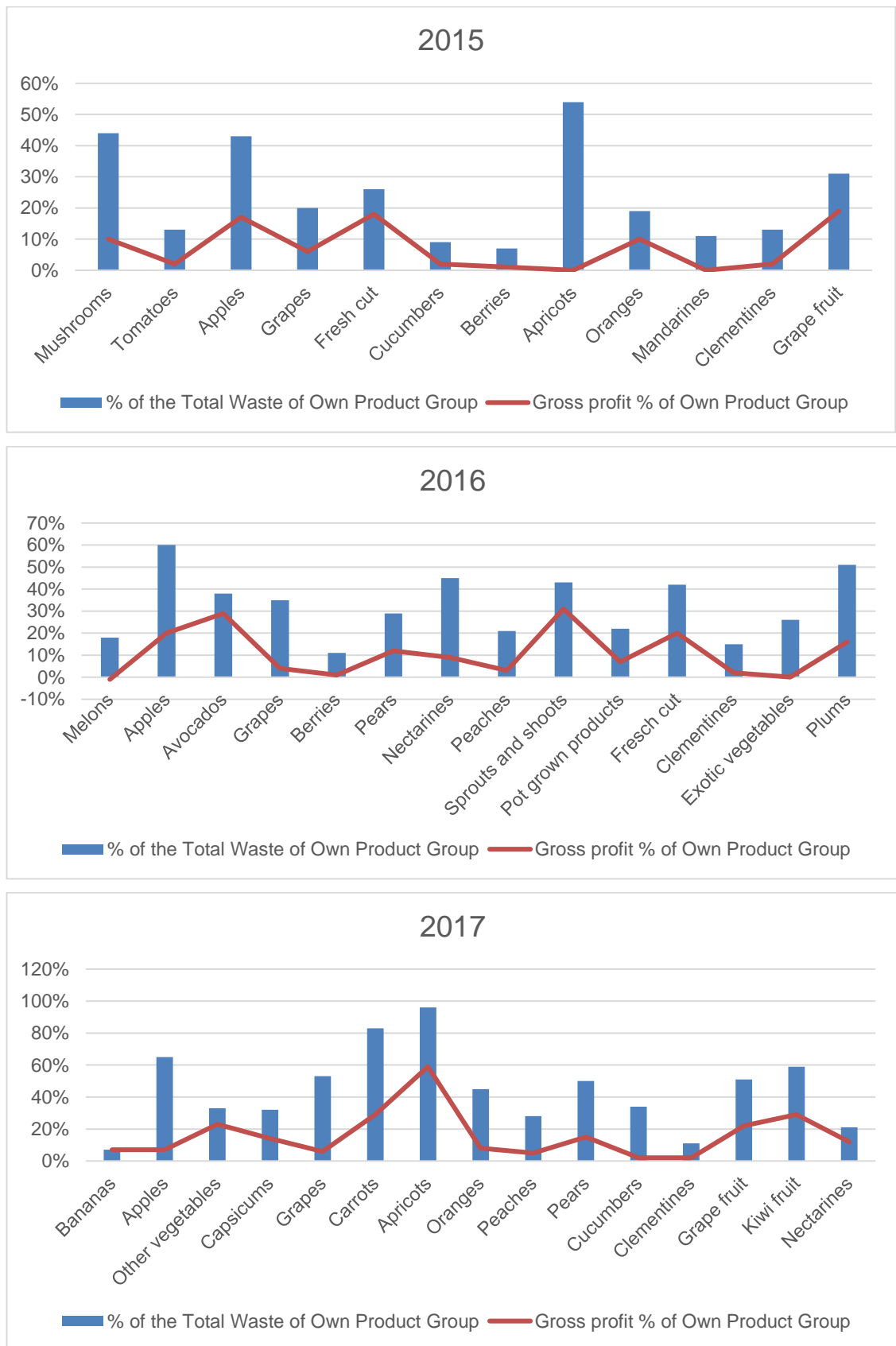
Figure 8: Organic products in 2015, 2016 and first half of 2017, which caused more waste than profit in own product group:

As previously mentioned, the year 2016 saw an overall rise in all waste. The greatest amount of organic produce waste occurred during the months of March to August. During the month of July, 32% of the organic produce waste of the entire year was created. As an example, melons were the second biggest organic waste product group that year, right after bananas (Table 3). Most of the wasted melons were disposed of during the summer months from May to July 2016. These melons ended up in the waste and were not sold to the farmers' markets. None of these melons could be found in the Anomaly table for arriving produce. Interestingly, none of the organic produce wasted in July 2016 could be found in the Anomaly table. This likely means that on arrival the produce was in good shape but too much produce with short shelf-life was bought and the turnover was too low. According to quality inspectors, in summer the sales for foreign produce drops as the local produce takes over the markets. In addition, many of the wasted products, like nectarine and grapes, have a short shelf-life to start with. Summer is also the time when most staff take holidays so both the routine and duties are affected by this.

197005 Banana Fair Trade Organic (EC)	-12241
198699 Organic cantaloupe melon 6kg (IT)	-3632
197860 Organic pear 10kg (AR)	-2514
197080 Organic orange 6kg (ES)	-1106
198155 Organic nectarine 4kg (ES)	-889
198030 Organic grapes dark 10X500g (IT)	-802
198050 Organic peach 10X500g (IT)	-770
198165 Organic apricot 10X500g (IT)	-578
198761 Organic honey dew melon 6KG (ES)	-527
198937 Organic aloe vera (ES)	-448
197001 Banana Fair Trade Organic (EC)	-372
198777 Organic galia melon 5KG (ES)	-367
198704 Organic mini water melon 16KG (ES)	-326

Table 3: Organic produce wasted in July 2016 (Company x, 2017).

7.1.2   The Anomaly table, arriving produce

As mentioned in chapter 4.2, when produce arrives at Company x, it is inspected by the quality inspector. If any visual problems are observed, it is then recorder in the Anomaly table. During this thesis project, this Anomaly table for arriving produce was used to compare how many times organic produce appeared on it and for what reasons, and also to see how many times a proviso product leads to waste. The investigation into this

matter revealed that 21,3% of the items appearing on the Anomaly table are organic products. This could easily lead to the assumption that a fifth of all waste at Company x is from organic produce. However, many of the items appearing on the Anomaly table did not lead to waste. This means that although there was a problem on arrival, for example when some clementines were mouldy, this did not spread through the rest of the produce and cause more waste. Also, sometimes the organic produce did simply have a problem with a label and this is not waste per se, although it appears in the Anomaly table.

A further investigation into the trash accounts revealed that 78,5% of the conventional produce mentioned in the Anomaly table ended up in the waste in the same or following month (Table 4). From this we can conclude that if a product appears in the Anomaly table, then this is a good instigator that some amount of the same product will end up wasted. If a product has quality problems on arrival, it will likely lead to problems later. Surprisingly there is a slightly lower chance (70,5%) that an organic product appearing in the Anomaly table will end up wasted. This strengthens the observation that most of the total organic produce wasted did not previously appear in the Anomaly table although it ended up wasted. It is therefore likely that the organic produce arrived in poor condition but it was not noticeable.

Product	Year	
	2015	**2016**
Conventional	77 %	80 %
Organic	68 %	73 %
Together		75 %

Table 4: The share of products appearing in the Anomaly table and then ending up wasted.

7.1.3   The Anomaly table, produce discarded after arrival

As we have seen, the waste statistics are not explicit as no reason is recorded for the disposal. Therefore, during the weeks 12 to 14 in March 2016 and 24 to 26 in June, together with the terminal workers and quality team, surveys were conducted to record the reason why produce was wasted. The reasons were divided into seven categories. The monetary value of each discarded product was recorded under each category (Table 5). This study helped to map out the reasons why the products were wasted and the

costs for each category. The categories 3 and 4 represent together 48,5% of the products. These are products that were in such a poor shape they could not be sold to the customers. These products were either sorted out during the daily quality inspection, were damaged during the storage time or arrived in poor shape. Pre-ordered products (Category 1) were bought by Company x because customers had specifically requested them but finally did not end up buying them. Therefore, the products wilted in the storage and were disposed of. Date labelling was a reason behind 10% of the waste. These products are removed from the storage just before the best-before date. Customs (Category 7) also take samples of some of the products to test them for diseases and pesticides.

Category	Label	Description	Share
1	Pre-ordered product	Products bought to customers' orders but orders not fulfilled.	3 %
2	Dated product	Products disposed of due to best-before date.	10 %
3	Old or Poor shape (also dried out, mashed up, frostbitten, broken)	Products disposed because of wilting, dark spots, drying out or old appearance etc.	46,5 %
4	Mold	Mold found in products.	2 %
5	Refused by customer	Take-back agreement (TBA) products	37 %
6	Other	Products transferred between two storage accounts.	0,5 %
7	Customs sample	Customs ramdom sampling.	2 %

Table 5: Waste survey results by categories, months of March and June 2017.

In this four-week survey, products refused by customers represented 37% of the waste. These take-back agreement (TBA) items are products that were delivered to a customer but the customer refused them and returned them back to Company x. The reason for a return could be the poor shape of the product or mould, for example. Often just a small portion of the products is diseased but the entire pallet gets returned (Interviewee B, Company x). According to the quality team the amount of returns we received during week 12 to 14 were considerably higher than during most of the year. This was due to the reason that a big supermarket chain opened a new store and they were exceptionally strict with the delivered produce. As the survey was conducted only for a short period of time, we repeated the survey in June, to get more accurate results. Surprisingly, the

share of the returns remained the same: in March it was 35% and in June 39%. Consequently, it can be stated that TBA is a considerably high waste category.

7% of the products in the survey were organic. In organics, the categories 1, 2 and 3 had all slightly higher results than conventional produce and category 5 was 21%. However, as the organics represented such a small share of the costs, the results must be viewed with caution.

The results of this waste survey showed that half of the waste is caused by a combination of aging, low quality, samples, accidents and other reasons, which are partly unavoidable, and partly due to the low turnover of products. We found several instances of products being wasted because of deterioration, softening or sprouting, all of which are the result of the product spending more time than necessary going through the supply chain.

The other half of the waste (categories 1, 2 and 5) is, to a great extent, avoidable. This waste is further discussed in chapters 7.2, 7.3 and 7.7.

The results of the four-week waste observation, anomaly table and account examinations, as well as interviews have brought me to the conclusion that the cause for a higher percentage of waste from organic produce compared to the gross profit from organic produce, is a combination of low turnover, invisible shelf-life loss, and the price of the organic produce. Organic produce has a low turnover, meaning that the turnover is smaller and slower, than with conventional produce. Product groups with low turnover tend to have higher waste than product groups with high turnover. As an example; Asian products, apricots and mini vegetables are all small profit product groups with high waste.

In a retail food waste study by Eriksson, Ghosh, Mattsson, L., and Ismatov, A. (2015), focusing on supermarkets in Sweden, it was found that the relationship between turnover and waste percentage was the same for organic and conventional products, when the organic products were sold with low turnover and high wastage. Turnover, or a low sell rate in this study, was sold mass over time. For both organic and conventional products with low turnover, the shelf-life and wholesale pack size were found to be critical in determining the waste percentage. Smaller packages created less waste. It was determined, that disclosing and reducing the products with low turnover would most likely reduce overall waste, but this is often not possible to carry out because there are envi-

ronmental policies that make decreasing the organic range offered by supermarkets impossible. In addition, increasing the turnover of organic products takes time to achieve (Eriksson et al., 2015).

The organic produce costs an average 33% more than conventional produce (Company x, 2017). With a low turnover, this waste becomes expensive and should thus be avoided. Because waste from organic produce is costly, it must be weighed up which is more damaging for Company x: the lost sale of some organic product or the lost organic product.

7.2   Date Labelling

Date labelling is a common cause for food waste. As we have seen at Company x, it is the reason behind 10% of costs for products being wasted. These are packaged products like lettuce leaves, sprouts, root vegetables, melons and pineapples. According to food waste campaigner Tristram Stuart, date labelling is also the biggest area of confusion amongst consumers, as many people treat a best-before (quality) date as if it were a use-by (food safety) date and throw away food because they believe it is unsafe to eat. The research by UK Waste and Resources Action Programme (WRAP) has indicated that most of the avoidable food waste generated annually in UK households is associated with households obeying date labels, and not using or freezing products before the end of the use-by date regardless of whether the product is still edible (WRAP, 2009).

In Company x, the expiry dates of arriving products are not recorded anywhere so it is up to the quality team to monitor the dates. The quality team checks the dates daily during the quality inspection and reads the expiration date on each product unit to determine which product units are approaching or have passed their expiration dates. This process is time consuming and is subject to error. Products with too short shelf-life are pulled from the shelves so that they would not go through picking and be delivered to retailers. Retailers will refuse to take products with insufficient shelf-life remaining. This is in part because the end customers prefer fresh products over those with only a short shelf-life remaining. In most cases, when retailers take over products from wholesalers or producers, the remaining shelf-life must be 60 to 75%. (Canali, Östergren, Amani, Aramyan, Sijtsema, Korhonen, Silvennoinen, Moates, Waldron, and O'Connor, 2014). At Company x, most of these products are then disposed of and only a fraction of them are sold to the farmers' markets.

Fruit and vegetables sold in packs are required to have a date label. In Finland, the general provisions applying to the labelling of food products are prescribed in the Decree of the Ministry of Trade and Industry on the Labelling of Foodstuffs (724/2007 and 1224/2007). As stated in law, products which are microbiologically highly perishable must be labelled with a use-by date. Apart from a few exceptions all other packaged products must be labelled with a best-before date. However, the products can be sold or used after this best-before date. Products which do not require best before dates are, for example, fresh berries, fruit, vegetable and mushrooms (but not sprouts) which have not been peeled, chopped or processed in any way (Evira, 2016). For this reason, products like washed potatoes and carrots, and sliced pineapple have date labels in Finland and quite often, despite being perfectly edible, if not sold before the date on the label, they become waste.

Although in most countries it is legal to sell products past their best-before date, it is not clear how to handle such products. Legal authorities do not give official advice on this topic. In fact, most food charities do not offer such products as it is too dangerous to them if something happens (Canali et. al., 2014). Governments should bear some responsibility for educating the public on date labels. Mr Stuart believes that in a lot of cases the best-before marking is not even necessary. More importantly, the EU's Food Labelling Directive states that it is illegal to use a labelling system that confuses customers (Stuart, 2009).

It has been suggested that some legal restrictions regarding date labels should be revised. As an example, the EU directives have set the use-by date for an egg to be 28 days from the laying day. This mandates Nordic egg producers to set very short best-before dates because in southern Europe eggs are stored differently and they also have the risk for containing salmonella. Since this is not the situation in the Nordic countries, it has been proposed that extending dates in these countries would save a lot of eggs from going to waste (Canali et. al., 2014).

Managing the inventory of products in relation to expiry dates is thus a key component of waste management. There is a need for an efficient and accurate method of tracking product expiration dates to improve inventory management and assure that perishable products can be sold before their expiration dates. In Company x, recording the expiry dates in a data base for all personnel to see could be a good prevention method as this

way the responsibility of monitoring expiry dates could be shared between the buyers, sellers and the quality team. A computerized inventory control spreadsheet or software would be the best applications. Another option would be to send a daily list of items with approaching expiry dates to the sellers, and the products could be sold at reduced price. One more option would be to find a new, reliable customer willing to purchase these close-to-expiry products at discount price. Of course, all of these suggestions require new arrangements but it is my recommendation to test and evaluate them. To a certain extent, the disposing of dated products is avoidable as the 'day when the product becomes waste' is known ahead and there is often no quality issue with the product. Ideally, products with expiry dates would not go to waste as the only thing that is perished is the date on the label.

7.3   Take Back Agreements

Waste caused by reclamations was the biggest surprise to me, the researcher, during this thesis project. In fact, this type of waste did not come up at all during my pre-thesis literature review as very few studies have mentioned it. Nevertheless, it is a reality, and it needs more attention. Reclamations happen when the customer rejects the delivered product and reclaims the cost of it. One of the few scholars to have researched the subject is Phd Mattias Eriksson from the Swedish University of Agricultural Sciences. In his study conducted in 2015, it was found that FFV reclamations contributed to 67% of the wasted mass from six retailers during five years of investigation (Eriksson et al., 2015). It can therefore be argued that even though this is a little-known problem, it is a potential hot spot for waste reduction.

According to Eriksson (2015), product reclamation is an easy way for retailers to reduce the cost of waste, simply by letting the supplier pay instead. Usually the retailer reclaims the value of some delivered goods that were not fulfilling the requirements of the contract between the supplier and retailer. Ideally the reclamation includes a physical rejection of the goods at delivery. This way, the supplier can immediately take the produce back. Eriksson calls the product reclamation process a Take Back Agreement (TBA) and the items rejected by store at delivery, pre-store waste. This waste, which according to the rules must be reclaimed within 24h of delivery, belongs to the supplier in accounting terms but is often discarded at the supermarket (Eriksson, 2015).

Reclamations are common at Company x too. A few of the customers of Company x are especially sensitive and they reclaim products for a small reason. Some might not reclaim often but when they do, the amounts are large. These customers do not sort through the pallets themselves but they return the entire pallets (Interviewee B, 2017). These TBAs often cause more waste because the produce is not properly stored while waiting for the return. If these products are not immediately returned to the warehouse of Company x for sorting, the cold chain could be interrupted and this may cause more waste. Therefore, although the customer reclaims one punnet, the process turns the entire pallet into waste.

Some other customers reclaim produce due to cosmetic reasons, i.e. berries that have no quality issues but look ugly. Fortunately, most of these products can be sold to the farmers' markets or once the inferior quality produce has been sorted, to other customers (Interviewee B, 2017).

The rigid specifications required by retailers have been identified as driving waste in the retail supply chain. For FFV, goods of 'inadequate' quality are returned, and retailers have a sole the right to determine the quality. This poses a risk that unsold fruit and vegetables could be categorised as inadequate quality and returned to suppliers (Eriksson, 2015). Also, according to Canali et al. (2014), TBAs can lead to food waste since the staff at retailers are not incentivised to order the optimum number of products when the cost of oversupply is covered by the supplier. This lack of incentive to reduce food waste at the place where it is generated is a major risk factor for food waste.

Of course, many times customer have a good cause for reclaiming the products, as mouldy, old or rotten products should not be delivered. The Finnish Food Safety Authority Evira sets the minimum quality requirements for the products supplied to retailers. The produce must be whole, healthy looking and clean, and must not contain mould. It must be able endure handling and transport. Also, the produce must be ripe or in the process of ripening. Produce picked too early may not ripen. Every batch is allowed 10% waste tolerance for products which do not qualify to these minimum standards, apart from mouldy or rotten products which are never allowed. In practice this means that the 10% can contain products which include pests or damaged caused by pests, be torn or split or may include slight spoilage or dirt (Evira 2016).

Even if retailers follow these quality standards and those set by their binding contract, the package size could cause a problem. Most suppliers and wholesalers separate damaged or spoiled fruit from the batch during picking. Often this cannot be done by retailers due to logistics and labelling as a punnet with one less fruit will not be the same weight as that advertised on the label. Current practice is that the whole punnet is usually discarded even when most fruit within the punnet are perfect and fit for human consumption.

A possible waste-reducing measure at Company x could be to limit the scope for reclamations. As stated by Eriksson, (2015), limiting reclamations was the measure with the lowest cost or management intensity and had the highest prevention potential or intrinsic recoverability. At Company x, the reclamations are always investigated to find out whether the product was spoiled when leaving the warehouse or if it was damaged during the transportation. The quality inspector coordinates the enquiry with the buyers and records it into the system. If the product is just a little faulty and has, for example, a cosmetic problem, the customer can keep the product and a part of the price is refunded. If the product is completely damaged, then the customer can either discard it and be refunded or the products are picked up and returned to Company x.

TBA is always a cost for the supplier because it creates more time waste in working hours from drivers, quality inspectors and sales personnel, or physical waste, which is a cost because the produce must be disposed of and finally, it is a loss of sale. TBA could also be the combination of all of these costs. Consequently, it is advisable to keep a track record of the customer returns and bring up the subject in negotiations with each problematic customer individually. By collecting the data on customers, amounts, dates and products it will be possible to find out about continuous quality problems regarding products, suppliers, delivery companies or the picking process.

7.4   Inventory management methods

Keeping a track of product numbers, locations and expiry dates is a core function of a warehouse management system. There exist many inventory management methods for organizing, handling and prioritizing of stock, of which First in, First out (FIFO), is commonly used. This stock management practice assumes that the first bought units of stock are also the first ones to be sold. The FIFO-inventory management is in use at Company x, meaning that first arrived batch of a product is always delivered to a customer before new batch. Another inventory management method that is also used for fresh fruit and

vegetables is FEFO: First Expired, First Out. The FEFO system takes into account the estimated remaining shelf-life of every product, and delivers products in that order.

The classical FIFO method seems to be a logical choice in stock rotation, as it ensures that stock is delivered based on its arrival date. However, this method assumes that all products arriving on a particular date have the same shelf-life potential, which often is not the case. Batches with short shelf-life should be sold and delivered as quickly as possible to reduce losses (Hertog, Uysal, McCarthy, Verlinden, Nicolaï, 2014). At any given time, the warehouse of Company x could contain numerous batches of the same product, with each batch of stock having a different yet unknown storage lifetime. This situation creates a problem in that the first batches to arrive could have a longer shelf-life than the following batches but the first ones will be delivered first. Consequently, the following batches may end up expiring before delivery and turn into waste.

A FEFO approach implies that products will only be delivered depending on their shelf-life potential. By implementing this method it is likely that some unnecessary losses due to perishing goods can be prevented and economic losses minimized. However, the implementation is not as straightforward and simple as the FIFO method. The transition to a FEFO strategy requires both information sharing between trading partners in the supply chain regarding the products' history, and technology. Potential data sources for establishing useful shelf-life estimates include environmental data, such as the growing conditions including weather, information of previous season's batches received from the same location, the temperature at pallet or product level and ethylene levels. Ideally the supply chain managers would be able to view the complete history of any product across primary production and secondary processing and distribution (Hertog et al., 2014). The accumulated environmental condition data is then used by the warehouse management software to automatically calculate the remaining shelf-life of a product, and to match the variation to inventory rotation, routing and special handling (Jedermann, Nicometo, Uysal and Lang, 2014). Presently, there is a lack of automated data collection and shelf-life calculation systems in the industry and for these reasons the FEFO method is not widely is use.

The remaining shelf-life of a fruit or vegetable product is often hard to measure or impossible to tell just by looking at a product. A punnet of fresh strawberries might last for seven days or it might change into a mouldy soft texture the next day. The same way an

avocado might look fine from outside but be brown inside. As the quality of a fresh product is not a static parameter but a highly dynamic variable (Hertog et al., 2014), predictive measures are required to estimate quality changes and remaining shelf-life.

A study by researchers at the University of Florida Research Center for Food Distribution and Retailing showed how inefficient it is to only use physical inspection. In the experiment, full truckloads of Mexican blackberries were subjected to 4 hour delays in pre-cooling as well as no pre-cooling, before being shipped across the USA to retail sales. The experiment showed that most of the waste only became visible at the retail stores, even in the pallets with up to 92% of waste. The problem had occurred at an earlier stage of the supply chain but because it went unnoticed, the retail segment was blamed for these losses (Nunes, Nicometo, Emond, Melis, and Uysal, 2014).

In order to implement the FEFO, the supply chain partners would need to use holistic measures to synchronize the traded product information using similar languages, formats and structures and make this information available in the correct way at the correct time (Hertog et al., 2014). Experts from different fields of science, technology and biology have come up with solutions such as ethylene detecting containers and packaging, generic shelf-life models to predict the product's behavior and statistical process control to aid the procedure. Statistical process control means monitoring, controlling variables and, ideally, improving a process through statistical analysis. For example, the 'process' could refer to 'climate control in the supply chain' while the 'variables' are the climate conditions realized (Hertog et al., 2014).

The radio-frequency identification RFID, GPS and sensor technology applications are gaining popularity in the fresh produce supply chain to measure and log the product's conditions. The Mexican blackberry study used one temperature data logger per pallet, where the temperature logger was placed inside one of the cases on the pallet. The temperature monitors used were battery operated RFID tags, so that the data could be retrieved automatically upon receiving at the US warehouse. The data gathered showed that there was a significant temperature difference between each pallet, even with the pallets in the same trailer. This was likely due to incomplete pre-cooling processing. Yet, the shelf-life loss was not physical or visible. More so, 57% of these products did not have enough shelf-life for the longest logistic route it may have been sent through. The researchers used the knowledge of this temperature data to estimate the remaining shelf-life and matched the products to different logistic routes. This helped to reduce the

amount of products that were at risk of turning into temperature -related waste from 57 to 1% (Nunes et al., 2014). Most cold supply chain transport operators monitor the temperature of the air that pallets reside in. However, the container or trailer temperature can be misleading, because the temperature on a pallet level can vary significantly from the container or trailer temperature. It is the pallet level temperature that determines the rate of shelf-life loss (Nunes et al., 2014). As seen in the Mexican blackberry study, the FFVs may not have been properly pre-cooled, resulting in higher core temperatures than expected.

Generally, the FFV pallets are only inspected at key touch points, such as on arrival at packing house, wholesaler or at retailers. At each key touch point, there is a different quality inspector whose responsibility it is to ensure good quality is delivered, but who also have the competing objective to avoid reclaims from their own customers and quality losses. Each quality inspector does what they can to avoid losses. However, at these key touch points, produce is usually inspected only visually and this can be misleading, because often shelf-life loss is not visible until much later (Nunes et al., 2014). At Company x, the temperature of the pallets is checked on arrival with a portable device. However, this does not reveal the temperature history of the pallet.

As we have seen, monitoring the FFV temperature during the supply chain is beneficial. Currently, a product-level or even pallet-level temperature monitoring does not exist in most commercial perishable cold chains because of technological challenges and increasing cost (Nunes et al., 2014). Consequently, using a generic shelf-life model or algorithms to predict the internal pallet temperatures can assist the automated data collection. However, a study by Jedermann et al. (2014), found that quantification of the advantages of FEFO management by the percentage of avoided losses is unfortunately not so straightforward as several parameters of the cold chain, as well as their statistical variation, must be taken into consideration. Nevertheless, shelf-life prediction should not be based on a single quality factor like FIFO as sending pallets out on an FIFO and visible quality inspection basis can and does create waste, which can be avoided with time and temperature history and FEFO management. The success of this inventory management method will largely depend on the supply chain-wide willingness to participate in and contribute to the information sharing.

7.5   RFID ethylene detectors

Just as shelf-life loss on FFV can be hard to notice without the use of data or technology, another waste creating element is as hard to detect: the ethylene emission. Ethylene is a natural plant hormone, released in the form of a gas, that many fruit and vegetables produce. Ethylene production is induced during growth and ripening, and it increases as a result of bruising or wounding, and water and heat stress. (WSU, 2017b).

Many FFV both emit ethylene as well as are sensitive to it. When these FFV are exposed to ethylene, they ripen more quickly and give off more ethylene themselves, creating a domino effect that speeds up the ripening process for every other sensitive FFV nearby. Therefore, it is important to detect the high emitting FFV amongst the many in the storage so that they can be pulled out and put aside to avoid cross-contamination. However, on small amounts the odour of ethylene is not noticeable with human nose. The current methods for detecting ethylene are bulky, expensive, complex machines such as photo-acoustic spectroscopy or gas chromatography. These required instruments are laboratory level and require trained personnel. Handheld ethylene sensors are also available, but they are as well costly (Vergara, Llobet, Ramirez, Ivanov, Fonseca, Zampolli, Scorzoni, Becker, Marco, and Wöllenstein, 2007). So far, the reliable and low-cost detection of ethylene has remained an unsolved problem. The method or instruments used must be highly sensitive, able to analyse many samples quickly and to distinguish clearly between ethylene and other gases.

There is a need for new devices capable of monitoring FFV quality. The solution may lie with the RFID technology. Already ten years ago, first results from studies of RFID reader with a gas sensor were realised. A team of scientists funded by the European Commission was able to show that the RFID reader with onboard gas sensing capability is suitable for working as an alarm level monitor for apple conditions. This solution consisted of an RFID reader together with flexible tags that could detect the abnormal levels of ethylene, as well as abnormal levels of ethanol and acetaldehyde, which were signs that the apples were ripening too fast and suffering from respiration stress due to storage conditions (Vergara et al., 2007). Despite of this and various other studies on the subject, these smart, item-level RFID sensor tags are rarely used on perishable food due to their relatively high costs versus the cost of an individual perishable food item.

However, this might be changing in the near future. A start-up company called C2Sense has created a sensor chip with four sensing elements, including ethylene for fruit freshness, biogenic amines for meat freshness, and possibly humidity and carbon dioxide, on a single chip. The sensor can detect very low concentrations of ethylene and they can be attached to produce crates and shipping containers. A RFID chip is added to the sensor so it can communicate wirelessly with a handheld device. These chips are truly affordable as it costs only cents to produce each sensing element. The chips include new material, which is cheap to synthesize and reacts chemically with ethylene. The material was invented by a PhD student Jan Schnorr at the Massachusetts Institute of Technology and his research team. The sensors are exceptional as they are not only low cost, but also able to detect multiple gases and sensitive enough to detect low levels of the gas without setting off false positives (C2Sense, 2017). The company is currently taking steps towards commercialization by doing pilot projects with wholesalers and shipping companies. If a highly sensitive smart ethylene sensor can be achieved, these could replace currently operated analytical instruments.

These innovative strategies are needed for reducing produce spoilage. Measuring ethylene is key to food supply chain management to aid in these efforts. As a result, companies in food production, storage, transport, and retail, are all interested in the ethylene sensors. The constant monitoring of ethylene emissions from FFV can indicate the freshness status and can prevent transport of raw, over-ripe and spoiled produce to retailers. As well, the early detection of spoilage of FFV in storage or in transport can prevent total wastage of the entire stock. For Company x, taking part of a pilot project in such as the one conducted by C2Sense could help with solving this problem.

7.6   Key Performance Indicators

Successful waste management requires understanding, predicting, tracking and managing the data related to inventory and customer service. Key Performance Indicators (KPI) are used to measure the effectiveness of these objectives. With KPIs, a company is able to quantify their business objectives so they can regularly check up on their performance and determine where they are successful and where they need to improve. Every company must determine which indicators to record and monitor and there are several things to consider when choosing these benchmarks. These benchmarks could be based on

companies of similar size and business model within the wholesale industry that are doing well. The important KPIs are the aspects that will bring value to the company and business decisions, as well as help in more specific areas, such as waste management.

Some of the traditional supply chain management goals are reduced travel times, transport costs or product replenishment frequencies. However, at Company x, the supply chain planning should include more food-specific metrics, such as shelf-life-related KPIs, inventory and product quality KPIs. Analyzing which types of products are selling and at what quantities, and how quickly they are moving from the point of stocking can be particularly helpful. If the purpose is to forecast the demand, then data based on demand, not shipments, are needed. Shipments show when goods were shipped and not necessarily when the customer wanted them. Thus, shipments do not necessarily give a true indication of demand (Lillelund, J., 2015).

KPIs can also be used when working with clients. When companies begin a contract with a new client, the two organizations can agree on specific KPIs to track how successful the contract has been. Customers can also be divided into segments and the demand for each customer group can be recoded. The number of new customers acquired and customer retention metrics are also useful information. As discussed in chapter 8.3, collecting the data on the number, amounts and dates on reclaimed products, as well as the clients making these reclaims, could be valuable at Company x.

The high volumes, short delivery times and shelf-lives of the fresh food items, demanding service levels and high product quality, are a challenge for the procurement team at Company x. The key metric for forecasting is historical sales data, that can be used to build store level order forecasts. Other suitable metrics include service levels, forecast accuracy, spoilage of produce, and gross profit. Promotion-type forecasting separates out the promotion-related increase in demand from the estimated sales and evaluates the impact of future promotions based on previous promotions of the same type (Lillelund, J., 2015). In general it is always useful to record the circumstances relating to the data. Demand is influenced by particular events, and these should be recorded along with the demand data. Weather and temperature both at the supplier's side and at the destination are also significant factors that can be used in forecasting the demand, and therefore data on weather should be collected. Some examples of KPI for wholesalers are presented in table 6.

Demand forecasting	Past sales, Products' Price, Promotions, Seasonality, Events, Weather, Holidays
Product quality	Appearance, Shelf-life
Customer returns	The number of times times, which products, what amounts
Weather	At the farm and destination
External influencing factors	Calendar events and promotions, advertisements
Products	Suppliers, Sales and Stock information
Service levels	Customer complaints, New customers

Table 6: KPI useful for wholesalers.

Many companies use demand forecasting tools to help with replenishment management. Finland's leading chain of department stores Stockmann wanted to improve the availability of items at the grocery stores and chose the software company Relex Solutions to help with the project. Relex used over 3,000 forecast model combinations and numerous parameters including historic sales patterns, seasonal effects, supply days, minimum order quantities, and other such data to build the software. Now Stockmann forecasts for seasonal, campaign and holiday sales have significantly improved, as well as a 40% loss in reduced waste on average has been achieved (Relex Solutions, 2017). Likewise, a grocery wholesaler and supply chain service provider Tuko Logistics uses Relex Solutions. Their original replenishment process of fresh produce required the collection and monitoring of inventory levels, sell-by dates and other replenishment information in separate systems. Combining the information and drawing conclusions from it to support daily replenishment operations was a tedious and labor-intensive task, as hundreds of different fresh lines are replenished in the central warehouse environment. Relex Solutions helped to integrate and synchronize these daily operations with Tuko's customers' business processes. This resulted in improved product availability and forecast accuracy and cut inventory spoilage of produce. Some of Tuko's suppliers now contribute to the costs in exchange for access to forecasts because they are so accurate it helps them plan and save money (Relex Solutions, 2016).

Despite of this, the Relex Solution is best suited for non-fresh products. The FFV involves so many different variables like quality, competitor's price, competitive products and campaigns that even the most sophisticated software will struggle to give accurate forecasts. Also, the appearance and product placement of FFV affect their sales. Unappealing produce will simply not sell. In addition, the software is unable to record one of the most valuable measures in business: unmet customer needs. Although empty shelves mean zero waste created, an unfulfilled customer demand can be disastrous for business, as the it means a lost sale and possibly a customer as well (Interviewee D, 2017).

7.7   More food for thought

As demonstrated by the previous chapters, produce waste is a complex subject and there exist no single right solution to solve the problem. Here are some more suggestions to consider:

Reduce waste from pre-ordered produce

Pre-ordered produce means products that have been bought by Company x specifically because a customer ordered them. The order for these products must be placed a few days before the client receives the order. Every so often a client cancels an order. This could be due to a mistake because some clients do not realize or remember that a certain product requires pre-ordering and therefore it will not be delivered in the following days. In this situation, it is the responsibility of the seller to find a new client but this does not always happen, and the product goes wasted (Interviewee B, 2017). This should not be happening as this waste is easily avoided. I recommend monitoring the pre-ordered products to see where the problem arises. To avoid the mistakes, some clients might require a reminder list of the pre-order products.

Staff incentives

Incentives often motivate the workplace culture in the direction the management desires to go. To this end, a staff bonus or voucher for waste reduction might be worth considering. Although waste reduction is part of Company x policy and strategy, an effective approach would be to motivate the staff to conform to this target. However, there is a possibility that a target such as 'waste reduction' would have an adverse effect, if the poor-quality produce is sent to the clients, just to keep the figures down. Therefore, incentives for a real, transparent waste reduction are required. For example, the staff could be rewarded for finding new clients who are happy to purchase 2nd class produce. This way the produce that is not suitable for the farmers' markets is channelled off to appropriate markets instead of being disposed of. The staff can also be given a price for the best waste reduction ideas, or explore ways of better utilising the 2nd class produce or misshapen fruit. Everyone should take initiatives to control and reduce waste and be creative on how to reduce it. Bringing up the subject of food waste in staff meetings would certainly help to keep it in people's minds.

Easy access packaging

Another topic to consider is the isolated diseased FFV in a bag or punnet. When a box of grapes contains some mouldy fruit, the diseased fruit can usually be removed from the punnet and replaced with new, fresh fruit whilst not breaching legislation on weight misrepresentation. This is because the design of the grape box allows opening and closing without breaking the plastic box. A lot of FFV packaging is not designed to allow for opening and closing, for example the onion bags in a net (Figure 9). If such a bag contains a diseased onion, the entire bag is taken off the shelf and sold to the farmer's market, or disposed of. For this reason, easy access packaging should be favoured.

Figure 9: The different packaging designs help reduce or create waste. (Photo credits: Indiamart, 2017 and WAFresh, 2017)

Consumer preferences

Consumer education regarding FFV and waste from them could be a subject to focus on. According to some staff members of Company x, an underlying cause of FFV waste is the fact that Finnish consumers like to buy raw produce instead of perfectly ripe produce. This means that a lot of FFV goes wasted at peak ripeness as the consumers prefer to buy unripe produce instead. Often, it is not worth sending ripe produce to a store as it would simply be rejected and reclaimed (Interviewee B, 2017).

Although consumer motivations are complex and vary depending on gender, age, as well as cultural, ethnic, and regional background, the main objective of buying is to obtain satisfaction (FAO). For FFV, this means that a consumer desires to meet nutritional requirements as well as being able to enjoy different tastes, textures, colours and aromas. There is a growing demand for higher quality produce. External aspects that consumers

are seeking for concern the presentation, appearance, uniformity, ripeness, and freshness of the produce. These external aspects are the main factors in the decision to purchase, and this decision is taken when the consumer sees the product (FAO, 2011). Although consumers are driven towards perfect produce, there are some exceptions. For example, consumers have been 'trained' to accept the less attractive organic produce, because it is organic, and thus supposedly superior.

It has been stated in various studies (i.e. ReFed, 2016, Canali et al., 2014, Silvennoinen et al., 2012) that consumer education about food waste has a central role in tackling the issue. According to the survey Food Behaviour Consumer Research: Quantitative Phase by the Waste & Resources Action Programme WRAP (2011), poor 'home economics' skills, in general, are a strong driver of food waste. Consumers are not likely familiar with the concepts of storage of fresh produce, seasonal diets, organic farming or vegetarian food as well as planning meals and grocery shopping before entering the supermarket. In addition, 59% of the respondents to the WRAP survey also agreed that they would probably try to throw away less food if they had more information on the environmental impact (WRAP, 2011).

The consumers play an important role in the transition towards a sustainable economy through making choices and promoting them further. However, they need more education about food, food chains, food waste effects on environment, sustainability, waste management and packaging. The sustainable consumption habits should be promoted through campaigns and educational programs. For this they need guidance from the experts, such as wholesalers and retailers, food services, and catering professionals, who must join forces to promote seasonal, ripe and also 2nd class produce.

8   Conclusion

Food waste is as complex of an issue as the many definitions of it. Produce waste presents a particularly significant challenge because food is a human necessity, which production requires vast amounts of natural resources such as water, land and energy. Still, the prevention and reduction of waste is achievable, small steps at a time.

The research question was asking what were the causes and possible prevention methods for waste from organic produce at Company x. This study found that organic produce

did cause more waste than conventional produce, but the reason is likely a low turnover in combination with short shelf-life and not the organic label as such. Therefore, the focus should be on increased turnover of organic produce, but until this is achieved, measures that increase shelf-life and a better assessment of customer demand to ensure that stock is sold in time, are recommended. Care should be taken not to fault the waste on the organic label because if organic products are seen as a major cause for waste, there is a chance that consumers will lose confidence in organic products. Some organic produce may have a shorter shelf-life than conventional. However, it is more likely that the quality of the produce reflects careless product handling after harvest than the method of production.

Most of all, it is important to concentrate in overall reduction of waste and not just the organic produce waste. Company x should determine how big of an issue produce waste is. The emphasis of the FFV industry seems to be on cost, efficiency and availability. Although waste has an impact on all of these factors, it is not usually a key performance measure and it can be sacrificed at the expense of other performance indicators. Other aspects to consider are the technologies required to monitor food data throughout the food supply chain; measuring the reasons of food waste and publicizing results; new markets for best before-products that are discarded; and the new Anomaly table for produce discarded after arrival.

Joining efforts with other businesses could be helpful. For example, the Swedish Mat Smart is an online company that sells surplus and short-dated stock, meaning food that is either near or just passed its best-before date, to customers now in Finland as well. Wholesalers are able to redistribute their close to expiry-stock to this company and this way avoid waste and making a loss. This kind of innovation creates a win-win situation for all parties: the wholesaler, Mat Smart and the end-customer, who buys the close to expiry-product for a reduced price.

Further research on low turnover product groups would benefit Company x. Implementing a quality performance software, such as the aforementioned Muddy Boots would likely help with visibility by highlighting areas for improvement. In order to collect the most accurate data on the product groups with different variables, the KPI must be collected over a long period of time. Due to growing seasons, some products are only available for a few weeks a year. For these products, some years of data would only reveal the patterns in sales and demand. However, it is important not to get fixated with the past numbers. Being able to anticipate a growing or dropping demand and sell off close to

expiry products is a valuable skill in the procurement and sales team. It would also be beneficial to initiate a pilot project with some key customers and suppliers of Company x, and share produce waste, previous sales, and demand data with them.

What comes to measuring waste, it is important to stress that this study only considered economic value of food waste. When doing further research on waste, the definition and measuring units must be agreed upon with all parties. From a business point of view, measuring monetary value is ideal as it is universal and tangible. However, the measures in nutritional value or mass of waste are better ways to communicate the issue to people. Comparisons such as the number of humans that a certain amount of waste would feed per day, or the billions of tons of produce wasted per year, give a more concrete example of the problem to the average consumer.

In the recent months, food waste has been discussed a great deal in Finland in various forums but not many studies have been published. Further research on consumer attitudes and behaviors relating to food and food waste is also required. Surveys on this topic would most likely help to reveal what decision makers should be focusing on in the future by identifying where the areas of potential intervention or communication campaigns might be most effective.

Finally, it is a common misconception that reduced waste is always desirable for supermarkets and wholesalers. In reality, however, there will always be some waste in FFV business. The waste reduction measure must also be cost-effective in order to keep the business profitable, as only profitable companies will survive in the long-term. Thus, it is important to introduce measures that are both environmentally friendly while also increasing profits. For Company x, the key to solving produce waste is finding their own win-win solutions that will 'bear the fruit'.

9   References

Allais, I., and Letang, G., 2009. *Influence of mist chilling on post-harvest quality of fresh strawberries Cv. Mara des Bois and Gariguette.* International Journal of Refrigeration 32, Elsevier, Netherlands.

Aptean, 2017. *Extended warehouse management.* [Online] Available at: http://www.aptean.com/products/imi-supply-chain/extended-warehouse-management [Accessed 16.7.]

Bahinipati, B. K., 2014. *The Procurement Perspectives of Fruits and Vegetables Supply Chain Planning.* International Journal of Supply Chain Management, Vol. 3, No. 2, June 2014. Wiley-Blackwell, United States.

Bevan, J.R., Firth, C., Neicho, M., 1997. *Storage of organically produced crops.* [Online] Available at: http://orgprints.org/8241/1/Storage_organic_produce_report.pdf [Accessed 16.7.]

C2Sense, 2017. *Environmental monitoring.* [Online] Available at: http://www.c2sense.com/ [Accessed 16.7.]

Canali, M., Östergren, K., Amani, P., Aramyan, L., Sijtsema, S., Korhonen, O., Silvennoinen, K., Moates, G., Waldron, K., and O'Connor, C., 2014. *Drivers of current food waste generation, threats of future increase and opportunities for reduction.* FUSIONS Reducing food waste through social innovation, The European Commission.

Company x, 2017. *Company x orientation report.* Unpublished internal document.

Company x, 2017, Interviewee A. Name withheld.

Company x, 2017, Interviewee B. Name withheld.

Company x, 2017, Interviewee C. Name withheld.

Company x, 2017, Interviewee D. Name withheld.

Dries, L., Germenji, E., Noev, N, and Swinnen, J.F.M., 2009. *Farmers, Vertical Coordination, and the Restructuring of Dairy Supply Chains in Central and Eastern Europe*, World Development, Vol. 37, No. 11. Elsevier, Netherlands.

Eriksson, M., Ghosh, R., Mattsson, L., and Ismatov, A., 2015. *Take-back agreements in the perspective of food waste generation at the supplier-retailer interface.* Resources, Conservation and Recycling. Volume 122, 2017. Elsevier, Netherlands.

Eriksson, M., Strid, I., and Hansson, P-E., 2016. *Food waste reduction in supermarkets – Net costs and benefits of reduced storage temperature.* Resources, Conservation and Recycling. Volume 107, 2016. Elsevier, Netherlands.

Europarliament, 2016. *Parlamentti haluaa puolustaa maanviljelijöitä supermarketteja vastaan. (Farmers: how Parliament wants to help them earn a better living.)* [Online] Available at: http://www.europarl.europa.eu/news/fi/headlines/economy/20160613STO31999/parlamentti-haluaa-puolustaa-maanviljelijoita-supermarketteja-vastaan [Accessed 16.7.]

European Commission, 2017. *What is organic farming?* [Online] Available at: https://ec.europa.eu/agriculture/organic/organic-farming/what-is-organic-farming/international-trade-in-organics_fi [Accessed 16.7.]

Evira, 2016. *Vähimmäissäilyvyysaika ja Viimeinen Käyttöpäivä. (Shelf-time and Use-by date.)* [Online] Available at: https://www.evira.fi/elintarvikkeet/valmistus-ja-myynti/elintarvikkeista-annettavat-tiedot/pakkausmerkinnat/vahimmaissailyvyysaika-ja-viimeinen-kayttopaiva--ajankohta/ [Accessed 16.7.]

Evira, 2017. *Feeds and feed business operators.* [Online] Available at: https://www.evira.fi/en/animals/feed/ [Accessed 30.9.]

FAO: Food and Agriculture Organization of the United Nations, 2011. *Study on Global Food losses and food waste.* [Online] Available at: http://www.fao.org/docrep/014/mb060e/mb060e.pdf [Accessed 16.7.]

Han, Q., Gao, H., Chen, H., Fang, X., and Wu, W., 2016. *Precooling and ozone treatments affects postharvest quality of black mulberry (Morus nigra) fruits.* Food Chemistry, Volume 221, 2017. Elsevier, Netherlands.

Hertog, M.L., Uysal, I., McCarthy, U., Verlinden, B.M., and Nicolaï, B.M., 2014. *Shelf life modelling for first-expired-first-out warehouse management.* [Online] Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4006170/ [Accessed 16.7.]

Ibrahim I. Tahir, I., and Nybom, H., 2013. *Tailoring organic apples by cultivar selection, production system, and post-harvest treatment to improve quality and storage.* [Online] Available at: Life http://hortsci.ashspublications.org/content/48/1/92.abstract [Accessed 16.7.]

Jedermann, R., Nicometo, M., Uysal, I., and Lang, W., 2014. *Reducing food losses by intelligent food logistics.* Royal Society Publishing, United Kingdom.

Jurgilevich, A., Birge, T., Kentala-Lehtonen, J., Korhonen-Kurki, K., Pietikäinen, J., Saikku, L., and Schösler, H., 2016. *Transition towards Circular Economy in the Food System.* Department of Agricultural Sciences, University of Helsinki.

Kaipia, R., Dukovska-Popovska, I., and Loikkanen, L., 2012. *Creating sustainable fresh food supply chains through waste reduction.* International Journal of Physical Distribution & Logistics Management, Volume 43, 2013. Emerald Publishing, United Kingdom.

Kesko 2016. *Annual report.* [Online] Available at: http://annualreport2016.kesko.fi/gri-report/responsibility-programme/environment/ [Accessed 16.7.]

Ketola, J., 2016. *Kaupan ruokahävikki, mielikuvat ja todellisuus. (Food waste at retail, the vision and reality.)* [Online] Available at: http://kauppavalmennus.blogspot.fi/ [Accessed 16.7.]

Kotro, J., Jalkanen, L., Latvala, T., Kumpulainen, K., Järvinen, M., and Forsman-Hugg, S., 2011. *What can the Finnish food chain be proud of? MTT Agrifood Research Finland.* [Online] Available at: http://www.mtt.fi/mttkasvu/pdf/mttkasvu15.pdf [Accessed 16.7.]

Lillelund, J., 2015. *Manufacturing Business Magazine, Key Performance Indicators For The Supply Chain.* [Online] Available at: https://www.mbtmag.com/article/2015/02/key-performance-indicators-supply-chain [Accessed 16.7.]

Mena, C., Terry, L. A., Williams, A., and Ellram, L., 2012. *Causes of waste across multi-tier supply networks: Cases in the UK food sector.* International Journal of Production Economics, Volume 152, 2014. Elsevier, Netherlands.

Merriam-Webster, 2017. *Definition of proviso.* [Online] Available at: https://www.merriam-webster.com/dictionary/proviso [Accessed 16.7.]

Mokkila, M., Sariola, J., Hagg, M., 1999. The key factors in the harvest and postharvest treatments of strawberries. VTT, Technical Research Centre of Finland

NRDC Natural Resources Defense Council, 2015. *France moves toward a national policy against food waste.* [Online] Available at ://www.nrdc.org/sites/default/files/france-food-waste-policy-report.pdf [Accessed 16.7.]

Nunes, C., Nicometo, M., Emond, J.P., Melis, R. B., Uysal, I., 2014.
Improvement in fresh fruit and vegetable logistics quality: berry logistics field studies. [Online] Available at: http://rsta.royalsocietypublishing.org/content/372/2017/20130307 [Accessed 16.7.]

Organic Community, 2017. *Organic FAQ.* [Online] Available at: http://www.organic.org/home/faq [Accessed 16.7.]

Proluomu, 2017. *Luomun myynti huimassa kasvussa: +14 % vuonna 2016. (Sales of organic food up by 14 %.)* [Online] Available at: http://proluomu.fi/luomun-myynti-huimassa-kasvussa-14-vuonna-2016/ [Accessed 16.7.]

PTY, 2016. *Päivittäistavarakaupan myynti ja markkinaosuudet 2016. (The sales and market shares of retails companies 2016.)* [Online] Available at: http://www.pty.fi/ajankohtaista/tiedotteet/uutinen/article/paivittaistavarakaupan-myynti-ja-markkinaosuudet-2016/ [Accessed 25.10.]

ReFed, 2016. *Roadmap to reduce U.S. food waste by 20 percent.* [Online] Available at: https://www.refed.com/downloads/ReFED_Report_2016.pdf [Accessed 16.7.]

Relex Solutions, 2017. *Case Stockmann: Better replenishment management.* [Online] Available at: https://www.relexsolutions.com/case-stockmann/ [Accessed 16.7.]

Relex Solutions, 2016. *TUKO, managing a complex dc replenishment operation.* [Online] Available at: https://www.relexsolutions.com/wp-content/uploads/2016/06/RELEX-Case-Tuko_WEB.pdf [Accessed 16.7.]

S-group, 2016. *Case: Ruokahävikki minimiin.* (*Minimize food waste.)* [Online] Available at: https://www.s-kanava.fi/web/s-ryhma/raportit [Accessed 16.7.]

Silvennoinen K., Koivupuro H-K., Katajajuuri J-M., Jalkanen L., Reinikainen A., 2010-2012. *Food Waste Volume and Composition in Finnish Food Chain.* [Online] Available at: http://www.mtt.fi/mttraportti/pdf/mttraportti41.pdf [Accessed 16.7.]

Segrè A., and Gaiani S., 2012. *Transforming Food Waste into a Resource*. Royal Society of Chemistry Publishing, United Kingdom.

Sensire, 2017. *Temperature monitoring for temperature sensitive goods.* [Online] Available at: https://www.sensire.com/ [Accessed 16.7.]

Stuart, T., 2009. *Waste: Unconvering the Global Food Scandal*. W.W. Norton & Company, United States.

Tiersky, E., 2010. *Does conventional food have a longer shelf life than organic?* [Online] Available at: http://shelflifeadvice.com/content/does-conventional-food-have-longer-shelf-life-organic [Accessed 16.7.]

Vergara, A., Llobet, E., Ramirez, J.L., Ivanov, P., Fonseca, L., Zampolli, S., Scorzoni, A., Becker, T., Marco, S., and Wöllenstein, J., 2007. *An RFID reader with onboard sensing capability for monitoring fruit quality.* Sensors and Actuators B: Chemical, Volume 127, 2007. Elsevier, Netherlands.

Washington State University (WSU) Tree Fruit Research & Extension Center, Postharvest Information Network, 2017, a. *Handling organic fruit.* [Online] Available at: http://postharvest.tfrec.wsu.edu/pages/PC98U [Accessed 16.7.]

Washington State University (WSU) Tree Fruit Research & Extension Center, Postharvest Information Network, 2017, b. *The Role of Ethylene in Determining Apple Harvest and Storage Life.* [Online] Available at: http://postharvest.tfrec.wsu.edu/pages/N4I1C [Accessed 16.7.]

Waste and Resources Action Program WRAP, 2011. *Fruit and vegetable resource maps.* [Online] Available at: http://www.wrapcymru.org.uk/sites/files/wrap/Resource_Map_Fruit_and_Veg_final_6_june_2011.fc479c40.10854.pdf [Accessed 16.7.]

Wihuri, 2016. *Ympäristö / Jätteet. (Environment / Waste.)* [Online] Available at: https://aarnio.verso.fi/topic/jatteet?locale=fi [Accessed 16.7.]

Appendix 1   Waste and profit tables from 2015 to 2017

Content removed for confidentiality reasons.