Environmental Impact of Food Retailing

A comparative LCA of organic and conventional food products

Master of Science Thesis in the Master's programme Environmental Sciences at the University of Gothenburg

MALIN ERIKSSON

Department of Energy and Environment
Division of Environmental System Analysis
CHALMERS UNIVERSITY OF TECHNOLOGY
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Storage of apples in a Coop grocery store. © Malin Eriksson 2015.

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Abstract

The food chain in Sweden is estimated to contribute to one quarter of the total greenhouse gas emissions. Retailers have an important position, as the actor between the food producers and the consumer, to influence the supply chain. The aim of this thesis was to perform a comparative life cycle assessment to investigate the environmental impact of Swedish retailers handling of food products, and see if conventional and organic products are handled in different ways. The study also assessed the retailers opportunity to affect the environmental impacts in the food chain. This was achieved by studying six different food products; apple, banana, deep frozen cod, egg milk and pork. In order to gather information both quantitative and qualitative methods were used. Retailer data were collected from the Swedish retailer Coop through interviews and literature reviews. The study shows that retailers have a small contribution to a food products environmental impact, regardless of impact category studied. The activity that contribute the most to retailers environmental impact on food products is transportation, meanwhile warehouse, operational electricity and heating together only contribute to between 1-20 percent of the retailers total environmental impact. Organic production generates in general lower greenhouse gas emissions than conventional production, meanwhile conventional production results in a lower acidification potential and eutrophication potential than organic production. In future studies a greater collaboration with retailers is preferable in order to receive internal documents and more retailer specific data, this could result in a better understanding of retailers handling of food products and their possibility to affect the food chain.

Key words: *Retailers, LCA, Actors, Coop, Environmental impact and Food products*

Preface

This study is a master thesis in environmental science by Malin Eriksson within the master program Environmental Science at the University of Gothenburg. The project has been performed at Chalmers University of Technology within the project “Actor Based Life Cycle Assessment - towards green food chains for eco-products” by Birgit Brunkalus and Johanna Berlin.

I would like to thank my supervisor Birgit Brunklaus, Department of Energy and Environment, Chalmers University of Technology. I would also like to thank Mikael Robertsson, Former sustainability manager of Coop, Annki Schöld, Store manager Coop Extra Eriksberg, and Peter Rosendahl, Transport manager at Coop Sweden, for providing me with an understanding and information about Swedish retailing and Coop.

I would also like to thank my family and friends for your support, encouragement and willingness to listen to all my thoughts and reflections regarding my thesis.

Last, but not least, I would like to thank Fredrik Domhagen for his endless support, encouragement and constant cheering during this process.

Malin Eriksson
Gothenburg, 15 June 2015

Abbreviations

AP	Acidification potential
ASC	Aquaculture Stewardship Council
CO_2	Carbon dioxide
EP	Eutrophication potential
Eqv	Equivalence
GHG	Greenhouse gases
GWP	Global warming potential
ISO	International Organization for Standardization
KF	The Swedish Cooperative Union
KRAV	Swedish eco-label
LCA	Life cycle assessment
MSC	Marine Stewardship Council
NO_3	Nitrate
SCB	Statistic Sweden
SIK	the Swedish Institute for Food and Biotechnology
SLV	the Swedish Environmental Protection Agency
SO_2	Sulphur dioxide

Table of Content

1 INTRODUCTION 1

2 BACKGROUND 2
- 2.1 Eco-labelling 2
  - *2.1.1 KRAV 2*
- 2.2 Swedish retailing 3
  - *2.2.1 The Swedish Cooperative Union and Coop 3*
- 2.3 Sustainability and retailing 4

3 METHOD 6
- 3.1 Literature review 6
- 3.2 Interview study 6
- 3.3 Questionnaire 7
- 3.4 Life cycle assessment 7

4 GOAL AND SCOPE 9
- 4.1 Functional unit 9
- 4.2 Data sources and quality 10
  - *4.2.1 Geographical boundary 11*
  - *4.2.2 Time horizon 12*
- 4.3 Impact categories 12
- 4.4 Assumptions and limitations 12

5 DATA COLLECTION 14
- 5.1 Retailer 15
  - *5.1.1 Warehouse 15*
  - *5.1.2 Delivery 16*
  - *5.1.3 Electricity consumption 16*
  - *5.1.4 Heating 17*
  - *5.1.5 Storage at retailer 18*
  - *5.1.6 Turnover time 19*
  - *5.1.7 Sales ratio 19*
  - *5.1.8 Wastage 20*
- 5.2 Food production 21
  - *5.2.1 Apple 21*
  - *5.2.2 Banana 22*
  - *5.2.3 Deep frozen cod 22*
  - *5.2.4 Egg 23*
  - *5.2.5 Milk 23*
  - *5.2.6 Pork 23*
- 5.3 Transportation 23
  - *5.3.1 Refrigeration during transportation 24*
  - *5.3.2 Wastage during transportation 25*
- 5.4 Fuel production 25

6 RESULTS 27
  - *6.1 Retailer 28*
  - *6.1.2 Wastage reduction 30*
- 6.2 Sensitivity analysis 31

7 DISCUSSION 33
- 7.1 Result analysis 33

7.1.1 Handling of food products ... 34
7.2 Sensitivity analysis ... 34
7.3 Method analysis and data quality ... 35
7.4 Future research ... 35
8 CONCLUSIONS ... 37
REFERENCE ... 38
APPENDIX A – KRAV REGULATION FOR RETAILERS ... 42
APPENDIX B – INTERVIEW GUIDE AND QUESTIONNAIRE ... 45
APPENDIX C – SPECIFIC INFORMATION ABOUT THE FOOD PRODUCTS ... 49
APPENDIX D- TRANSPORTATION ... 54
APPENDIX E – INVENTORY RESULTS ... 60

1 Introduction

The production of food has a significant impact on the environment, affecting climate change, eutrophication, acidification, biodiversity and ecotoxicology, among others (Naturvårdsverket, 2014). The food chain in Sweden is estimated to contribute to one quarter of the total greenhouse gas emissions (Angervall et al., 2008). Previous studies on food products have showed that farmers in general, have the greatest contribution of a products total environmental impact, meanwhile "use phase" has the lowest (Angervall et al., 2008).

In the food chain there are several different actors, for example: farmers, cultivators, transporters, retailers and consumers. All actors have the possibility to make decisions that affect a products environmental impact; it can be the choice of cultivation method, choice of fuel, product handling or purchasing patterns. The choices will affect the total environmental impact of the product during its life cycle, cradle to grave perspective. For example: a reduced amount of wastage implies that less food needs to be produced and hence the environmental impact will be reduced.

This report is a part of a research project led by Brunklaus and Berlin. The aim is to develop an actor based life cycle assessment methodology focusing on green food chains for organic products (Brunklaus and Berlin, 2010). The purpose with this new method is to shift focus from an analysis of technical data to the analysis of actions and actors throughout the life cycle. In the food chain, where farming has the greatest environmental impact, retailers and customers frequently are forgotten. However, they have the possibility to influence the whole food chain (Brunklaus and Berlin, 2010).

To develop this new method three case studies will be performed, each study focusing on one of the three actors: industry, retailers and consumers. This master thesis studies the retailers and how they are handling conventional and organic food products.

The aim of this thesis is to perform a life cycle assessment to investigate the environmental impact of handling conventional and organic food products at retailers in Sweden. The study will also investigate if the retailers are handling conventional and organic food products in different ways, and if so how that affects the environmental impacts of the retailers. The products represent various food categories (fruit, dairy, egg, meat and fish) with different characteristics, storage demands and country of origin. Data for retailers in this study are gathered from Coop Sweden and general statistic. Coop were chosen since they have worked with environmental questions for over 45-years and contacts with Coop had already been made within the research project.

2 Background

There are two different food production systems studied in this report: conventional and organic production. To compare these productions system a variety of factors need to be taken into account, for example environmental impact categories such as eutrophication, acidification and global warming potential. It is, however, important to remember that sometimes the differences between two production sites can be larger than the differences between conventional and organic production (Nilsson, 2006).

Nilsson (2006) states that the most fundamental part in organic production is that no artificial fertilizers are used and only a small amount of pesticides with natural origin may be used in the production. The yield in organic production is, in general, lower compared to conventional production where fertilizers and chemical pesticides are used.

In order to market a product as organic it has to be produced according to the EU regulation. The regulation contains information on how the production should be done, labelling, the control of regulations and what applies for organic production imported from outside EU (Livsmedelsverket, 2015).

2.1 Eco-labelling

Eco-labelling, also called "environmental labelling", is a voluntary labelling system for products concerning environmental performance and information. According to Ecolable index (2014) there are, at present, 148 eco-labels around the world developed for food products. The procedure to receive an eco-label differs between different labels; such as different requirement and approaches. Examples of requirements that can be included in the label criteria are: methods of agricultural production, possible contaminations and social responsibility (Udo de Haes and de Snoo, 2010). For of the labels it is necessary to perform a certification process conducted by an independent quality assurance agency to receive the eco-label.

The ISO 14020-series have been developed for standardizing the environmental labelling globally (ISO, 2012). In the standard there is a distinction between two types of environmental labelling "Type I environmental labelling", the classic eco-label with a set of criteria that is needed to be fulfilled and a third-party review, and "Type II environmental labelling", self-declared environmental claims. There is also the "Type III environmental declaration" with pre-set categories of environmental parameters describing the environmental aspects of products.

Examples of eco-labels used for food in Sweden are Marin Stewardship Council (MSC), Aquaculture Stewardship Council (ASC), EU organic products label and KRAV.

2.1.1 KRAV

The organisation KRAV was founded in 1985 with the vision "*All production and consumption is sustainable and comes from a healthy earth*" (KRAV, 2014a). KRAV has, at present, 28 members represented by farmers, processors, trade and interest organisations for consumer, environment and animal welfare. The organisation develops and maintains the regulations for the KRAV-label, a type I environmental labelling for organically produced food. The regulation fulfils all requirements in the EU regulation (EG) nr 834/2007, the Swedish legislation and extended requirements developed by KRAV. These extended requirements include, among others, stricter animal welfare regulation, environmental policy and regulation concerning social responsibility (KRAV, 2014d). It is also possible for retailers, restaurants and the fishing industry to be certified according to KRAV-regulation. The requirements for retailers are presented in appendix A.

In Sweden KRAV is a well-known label; a survey conducted by TNS Sifo, on behalf of KRAV, shows that 98 percent of the Swedish consumers are familiar or rather familiar with the label, of these, 65 percent have a positive attitude for KRAV (KRAV, 2014b).

2.2 Swedish retailing

The Swedish food retail sector is dominated by three actors, which together cover 87 of the total market. Delfi et al. (2015) have compiled from 2014 which shows the market share of food retailing from Sweden's six largest actors in food retailing, see figure 1.

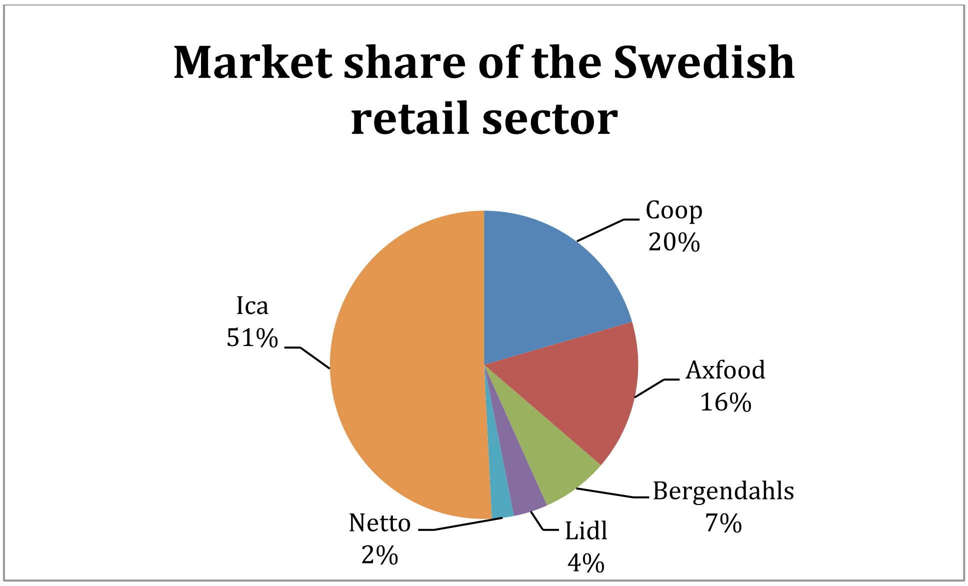

Figure 1: The six largest retail companies in Sweden and their market share in the food retail sector.

According to KRAV (2015b) Coop was the retailer that, during 2014, had the largest sales of organic products in terms of the total sales with 7,7 percent, followed by ICA with 4,5 percent and Axfood with 4,2percent.

2.2.1 The Swedish Cooperative Union and Coop

The Swedish Cooperative Union (KF) established in 1899, from the beginning they focused on supporting smaller cooperative financially (Coop, 2014a). Over the years they have grown and today KF is an alliance with 35 consumer cooperatives and 3,4 million members. Their goal business is retailing groceries through Coop Sweden AB. Coop has 665 grocery stores scattered throughout Sweden, 414 of these are owned by consumer cooperatives and 251 are owned by Coop Sweden AB, see figure 2 (Coop, 2015a).

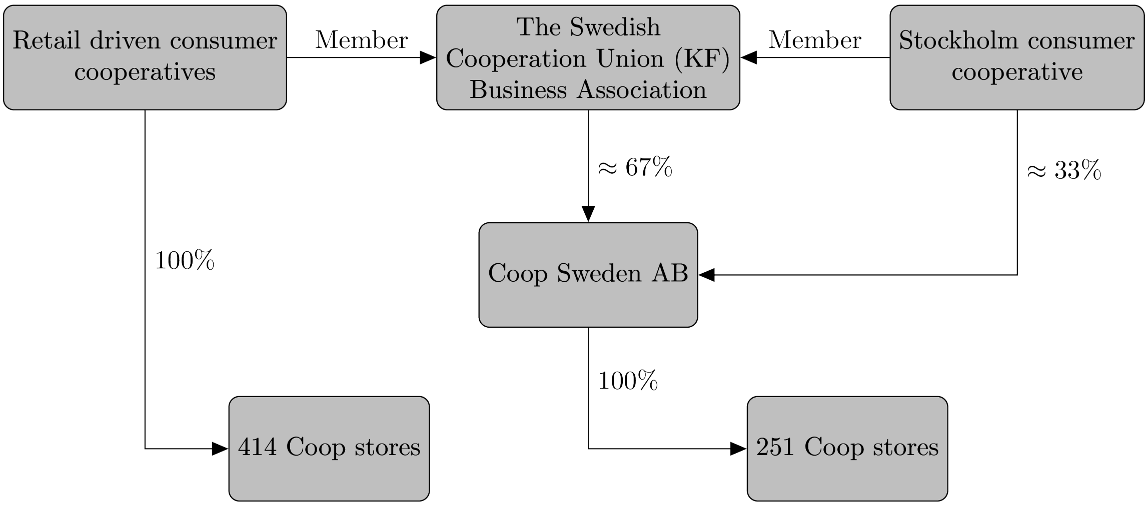

Figure 2: Ownership structure between KF and Coop (Coop, 2015a)

KF started their engagement in environmental issues in 1969, during this time the disposable packaging, which caused increasing dumping grounds discussed extensively. One year later they introduced an environmental council consisting of scientists from various disciplines (Coop, 2014d). In 1990 KF formed an environmental program, which includes the whole product chain. One of the goals within the program was to provide the consumer with an environmentally friendly alternative for all groups of food products (Coop, 2014c), e.g. vegetables, dairy products and meat. In 2013 Coops assortments of organic products amounted to 2395 goods (Kooperativa Förbundet, 2013). To reduce the emissions from their long range transports Coop started in 2009 to use trains between Helsingborg and Stockholm (Kooperativa Förbundet, 2010). Nowadays the train runs daily between Malmö and Bro transporting imported goods and goods produced in the south of Sweden (Rosendahl, 2015).

Since 2009 all Coop stores are certified according to KRAV (Coop, 2014a), this means that the stores, among others, have to provide the customers with a wide selection of KRAV products and how they are handling these products, energy use and choice of refrigerants (KRAV, 2015a). Two years in a row, 2011 and 2012, Coop received the Sustainable Brands award, an award based on a large numbers of customer research (Kooperativa Förbundet, 2013).

2.3 Sustainability and retailing

The European Commission (2009) states that: "*Sustainable consumption and production means using natural resources and energy more efficiently and reducing greenhouse gas emissions and environmental impacts*". This can, for example be achieved with better products and cleaner production (European Commission, 2009). Wiese et al. (2012) states that the food retailers position, as the actor between the food producers and the consumers, is important in the supply chain. Retailers have various ways of influencing the supply chain e.g. implementing standards regarding sustainability issues in the supply chain (Wiese et al., 2012), affect their products (Brunklaus and Raab, 2013) and processes (Wiese et al., 2015), and the opportunity to raise awareness by introducing more sustainable option in the stores (European Commission, 2009).

Retailers in Sweden work with sustainability in different ways. 800 retailers are certified according to KRAV (2015b) and around 170 retailers are certified according to Bra Miljöval (Naturskyddsföreningen, 2015b). Both of these certifications imply that the retailers have an active environmental work, such as reduction of wastage, energy consumption and a broad selection of sustainable products. A good understanding of the retailers role in the supply chain and their possibility to influence other actors makes it possible to suggest changes that would affect the food chain in a more sustainable direction.

3 Method

To gather information and data for this study, the following methods have been used; literature review, interviews and observations. The data have been used as inventory data and for environmental analysis.

3.1 Literature review

The literature study was done to give a current status report and background information on life cycle analyses of food, retailing activities and the products included in the study. The literature review also aimed to gather information about the environmental impact of the food products that are included in the study. Since the study focus is on Swedish retailers the information have mainly been collected from Swedish reports, authorities and Coops sustainability reports. The main sources are: the Swedish Institute for Food and Biotechnology (SIK), the Swedish Board of Agriculture, the Swedish Environmental Protection Agency, the National Food Agency (SLV) and Coop.

Scientific articles where found using the databases Web of science, Science direct and Google scholar using the keywords: life cycle assessment, retailer, supermarket, actor analysis and food products. The articles were selected with the criterias that the article should include two or more keywords and should be applicable to Swedish conditions.

Emission data used in the life impact assessment were collected from CPM LCA database (2013), Ecoinvent (version 3) and previous performed LCAs. More information about which LCAs and datasets that were used are presented in the section 4.2.

3.2 Interview study

In order to obtain information on how retailers are handling different food products, and if there are any differences between conventionally and organically produced products, qualitative interviews and e-mail correspondence were performed. The respondents are presented in table 1. In a qualitative interview, open-ended questions were asked the respondent in order to provide the opportunity to explain and specify the answer (Starrin and Renck, 1996). Interview questions were prepared before the interview, see appendix B. During the interviews it was also possible to discuss follow-up questions that arose.

Table 1: Summary of name, position and type of contact with the respondents.

Name	Position	Contact
Mikael Robertsson	Former sustainability manager of Coop Sweden between 1991 and 2012	Skype interview 10 Dec. 2014. Duration: 1h 40min Performed by: Malin Eriksson and Birgit Brunklaus
Annki Schöld	Store manager Coop Extra Eriksberg	Interview 3 Feb. 2015. Duration: 40min Performed by: Malin Eriksson
Peter Rosendahl	Transport manager at Coop Sweden	E- mail correspondence

The respondents were chosen due to different reasons. Mikael Robertsson, former sustainability manager at Coop Sweden, and Birgit Brunklaus, Assistant Professor at Chalmers University of Technology, had already established contact for the research project actor analysis. This since Robertsson has a great experience in Coops business and environmental work. During the interview Robertsson gave suggestions of two sale managers to contact, unfortunately one had recently resigned and the other one did not have time to participate. Due to this reason a questionnaire was send out, see section 3.3. Through the questionnaire a contact with Annki Schöld, store manager, was established. Peter Rosendahl, transport manager at Coop Sweden, was contacted since he has knowledge about transportation within Coop Sweden.

3.3 Questionnaire

To gather information concerning purchase patterns, amount of food wastage, electricity use and heating system a questionnaire was developed and distributed to all of the 15 sales managers at Coop stores in Gothenburg, see appendix B. The questionnaire was distributed through email with a text explaining the purpose of the questionnaire and what the data would be used for. After one week an email remainder was sent out and also several follow-up calls were done. The response on the questionnaire was minimal. Two sales manager replied and informed that the reason for not participating was: lack of time, the data requested was not compiled, lack of statistic and confidentiality. One of the sales managers, A. Schöld, was later interviewed.

3.4 Life cycle assessment

Life cycle assessment (LCA) is a tool used to calculate the environmental impacts throughout a product or activity's life cycle, i.e. cradle to grave. The LCA methodology has been standardized through the International Organization for Standardization and can be found in ISO 14040. At the beginning of the LCA process a system model is built. The model should include all processes included in the life cycle as well as inputs (use of resources and energy) and outputs (emission and waste) (Baumann and Tillman, 2004). Data for the processes are collected and quantified and calculations associated with the functional unit are performed. The functional unit express the function of the system, i.e. person*km when studying passenger transportation or kg product when studying food.

According to ISO 14040 the LCA framework consists of four phases. These phases are illustrated in figure 3 and are briefly explained below:

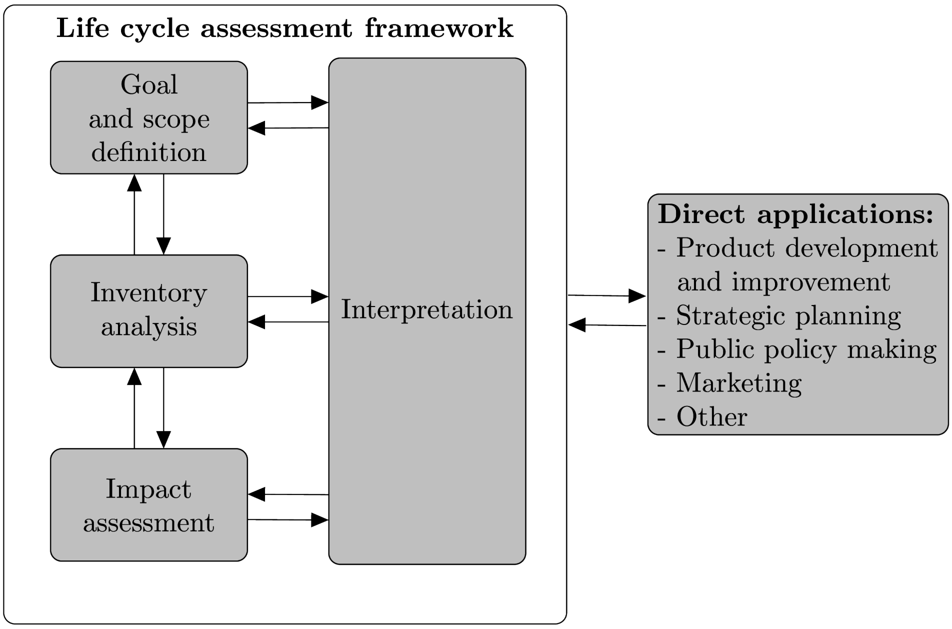

Figure 3: Phases of an LCA (Baumann and Tillman, 2004).

- **Goal and scope definition:** Defines the aim of the study and also which system/product that will be studied, including the reason for performing it and the intended application. The functional unit is defined, and will act as a basis for all calculations. Choices related to the modelling are made, such as the system boundaries and data quality. It may also be a good idea to do an initial flowchart for the system/product (Baumann and Tillman, 2004).

- **Inventory analysis:** In this phase a system model is created. A detailed flowchart is set up and data are collected for all activities that have been identified. The quantification of resource use (e.g. energy and raw material) and emissions are made in this step. When all data have been collected calculations of the environmental load related to the functional unit are performed. The inputs and outputs are now quantified. This phase can be quite time consuming since there are a lot of processes and technical systems to consider. (Baumann and Tillman, 2004)

- **Impact assessment:** In this phase the assessment and evaluation of the environmental impacts are made. This phase can be divided into two parts *classification* and *characterisation*. Classification is where the environmental load are sorted into the environmental impact categories they contribute to, and characterisation is where the assessment of the relative contribution for each impact category is made by multiplying it with a characterization factor (Baumann and Tillman, 2004).

- **Interpretation:** This is the phase where the result from the inventory analysis and the impact assessment are analysed in order to reach conclusions and recommendation. At this point it is also possible to perform a sensitivity analyse, test the robustness of the result or perform an actor analysis (Baumann and Tillman, 2004).

4 Goal and scope

The goal of this study is to investigate the environmental impact of Swedish retailers handling of food products, and more specifically if the retailers are handling conventional and organic food products in different ways, and if that affects the environmental impacts of the retailers. To achieve this six different products will be studied. The products represent various food categories (fruit, dairy, egg, meat and fish) with different characteristics, storage demands and country of origin.

The following research questions were used to determine the goal of the thesis:

- What are the retailers environmental impacts in the food chain?
- How large are the environmental impacts from the selected conventionally and organically produced food products?
- Which activity has the largest the environmental impact in the food production chain?
- Which actor has the greatest opportunity to reduce their environmental impact?

The study will also analyse how the retailer can affect their part of the environmental impact in the food chain for the investigated products.

The study focuses on the activities that a retailer has, based on the results from the interviews. The retailer activities identified are purchase of products, transportation, storing and selling, see figure 4. The chosen food products for the LCA are fruit: apples and bananas, dairy: milk, meat: pork, fish: cod and eggs. Both conventional and organic products are studied. These products were chosen since previous LCAs had been done for the production step of each product. Another reason is that the Swedish Society for Nature Conservation recommends the consumers to switch four of the six chosen product from conventional to organic since it, according to them, would make difference for both environment and people (Naturskyddsföreningen, 2012, Naturskyddsföreningen, 2015a). These products are apples, bananas, dairy products (milk) and meat (pork).

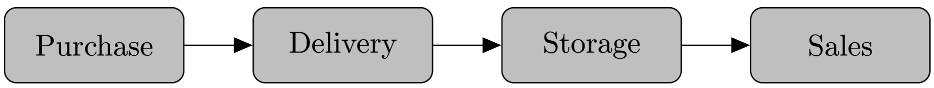

Figure 4: Flow chart illustrating a retailer handling of food products

In this study a comparative approach is taken with a focus on the retailer. There will be a comparison between the conventional and the organic food production, followed by a comparison of the retailer activities linked to the different food products.

4.1 Functional unit

The functional unit is determined to express the function of the system studied and this is the reference base for all the calculations made in the LCA. The functional unit used in the study is defined for each food product in table 2.

Table 2: Functional units for the food products included in the study.

Product	Functional unit
Apple	1 kg apple at the point of sale at retailer
Banana	1 kg banana at the point of sale at retailer
Deep frozen cod	1 kg of frozen cod the point of sale at retailer
Egg	1 kg eggs, in package of 6-eggs, at the point of sale at retailer
Milk	1 litre milk at the point of sale at retailer
Pork	1 kg pork the point of sale at retailer

4.2 Data sources and quality

The data collection can be divided into two parts foreground- and background data. Background data are related to the production of the food products. Data for the production is collected from articles, previous performed LCA and databases Ecoinvent (version 3) and CPM LCA database (2013). When comparing different LCAs, it is important that they have the same system boundaries; it has therefore been desirable to find LCAs that include both the conventional and organic production method. If that has not been possible the system boundaries and data collection have been studied to determine if they are comparable. In some cases, reports with inflows and outflows have been used and thereafter categorised.

The original idea was to collect data for the foreground system through a survey with Coop employees combined with interviews, and inventories and observational study at Coop supermarkets. Since the inventories were not possible to performed data needed to be collected in different ways. Instead two interviews were performed, M. Robertsson (2014), former sustainability manager of Coop, and A. Schöld (2015), store manager at Coop. The interviews resulted in an understanding of Coops organisation, how decisions are made, guidelines for retailers and personal experiences. For example purchase routines, transportation system and environmental work. Additional information about Coop was collected by visiting Coops webpage, reading Coop sustainability report from 2013 and through email correspondence with P. Rosendahl (2015), transport manager at Coop Sweden. When data gaps occurred, such as country of origin, sales statistic and energy consumption for cold space storage, other reports and studies concerning these topics were used.

Data for emission from transportation and electricity production are gathered from the databases Ecoinvent and CPM LCA database. Statistics, such as land of origin and sales statistics, are collected from Statistic Sweden (SCB). Table 3 present a summation of the information sources that have been used for the LCA calculations. Collected data were inserted in a Microsoft Office EXCEL spread sheet, where the calculations and classifications later were made.

Table 3: A summation of the information sources that have been used for each process in the LCA.

Process	Information source
Apple production	Davis et al. (2011)
	Sessa et al. (2014)
Banana production	Ecoinvent (2010)
	Roibás et al. (2014)
	Svanes and Aronsson (2013)
Deep frozen cod production	KRAV (2010)
Egg production	Sonesson (2008)
	Carlsson (2009)
Milk production	Cederberg and Flysjö (2004)
	Arla (2015)
Pork production	Carlsson et al. (2009)
	Sonesson et al. (2009)
	Ingvarsson (2002)
Retailer activities	Robertsson (2014)
	Schöld (2015)
	Rosendahl (2015)
Retailer data	Kooperativa Förbundet (2013)
	Carlson and Sonesson (2000)
	Energimyndigheten (2010)
	Statistiska centralbyrån (2014)
	Eriksson and Strid (2011)
	Gustavsson (2010)
Transportation and fuel	Hallberg et al. (2013a)
	Hallberg et al. (2013b)
	Hallberg et al. (2013c)
	Hallberg et al. (2013d)
	Hammarström and Yahya (2000)
	Winther et al. (2009)

4.2.1 Geographical boundary

Food products are produced around the world and imported to Sweden. The origin of product depends on season variations, culturing climate and customer demand. The country of origin of each food product is presented in table 4, the country of origin defines where the product is produced and the processes associated with the production will be related to that country. The geographical boundaries have been defined due to sales statistics from Coop (2014b) and Statistiska centralbyrån (2014). All products are assumed to be bought at a Coop-retailer in Gothenburg; hence the retailer data will have Sweden as their geographical boundary.

Table 4: Country of origin for the studied food products.

	Conventional	Organic
Apple	Italy	Italy
Banana	Costa Rica	Dominican Republic
Deep frozen cod	-	Norway
Egg	Sweden	Sweden
Milk	Sweden	Sweden
Pork	Sweden	Sweden

4.2.2 Time horizon

The goal has been to use as much of the latest data as possible. For Coop information the aim has been to find data from 2013 and 2014. Regarding the fruit production systems the time horizon varies, this depends on when the previous LCA that match the criterias were carried out.

4.3 Impact categories

The impact categories chosen for this study are: Global warming potential (GWP), Acidification potential (AP), Eutrophication potential (EP) and Energy use. Global warming potential is a measure of the potential of a greenhouse gas to contribute to climate changes. Greenhouse gases are emitted throughout the whole life cycle, especially from the transportation. Inputs of fertilizers during cultivation and breeding of pigs affects the eutrophication potential to a large extent. Acidification potential is caused by emission from, among others, the transportation. Use of energy occurs throughout the whole life cycle and is measured in primary energy; examples of primary energy are wind, water and crude oil. Table 5 submit the substances that characterize the different impact categories.

Table 5: The substances included in the characterisation indicators for the impact categories.

Characterisation indicators	Substances
Global warming potential (GWP)	CO_2, CH_4, N_2O
Acidification Potential (AP)	SO_2, NO_X , NH_3
Eutrophication potential (EP)	NO_X, NH_3, PO_4^{3-}, Total N
Energy use	Use of primary energy

4.4 Assumptions and limitations

The study consider a Coop store located in Gothenburg, due to lack of site specific data the result is for a general Coop store and not for a specific supermarket. The result could also differ if another retailing company were chosen, such as ICA or Willys.

Due to the time frame of the project it has not been possible to collect background data for the production of the studied food products, therefore previous LCAs have been used. In order to obtain comparable results for the conventional and organic production system the system boundaries of the exciting LCAs have been studied and the LCA with similar cut-offs have been chosen for the background system.

Coop has the ambition of only selling MSC, ASC or KRAV labelled fishes (Coop, 2015b). This is the reason why only the "organic option" for cod is included in the study.

Since this study focus on the retailer activities the consumer activities (e.g. cooking and waste) is not included, hence the LCA does not cover the entire life cycle of the food product.

Wastage losses at the retailer and the transportation to the retailer have been included in the LCA. Note, however, that the emissions from the food products waste treatment have been put at the consumer and are for that reason not included in the LCA.

5 Data collection

In this section quantitative data for the different steps included in the life cycle is presented. The data collected focuses on the retailer activities although information about the food products are also included. A flow chart of the general life cycle of a food product is found in figure 5. Milk is the only food product that does not follow this flowchart, milk is generally transported directly from the dairy to the retailer (Arla, 2015), see appendix C for milks flowchart. The other products included in the study are assumed to have the general product flow shown below. What differs between the products is how long time the products are located at the warehouse, fruits and eggs are for example only reloaded at the warehouse, meanwhile fish and meat can be stored up to ten respectively five days (Rosendahl, 2015).

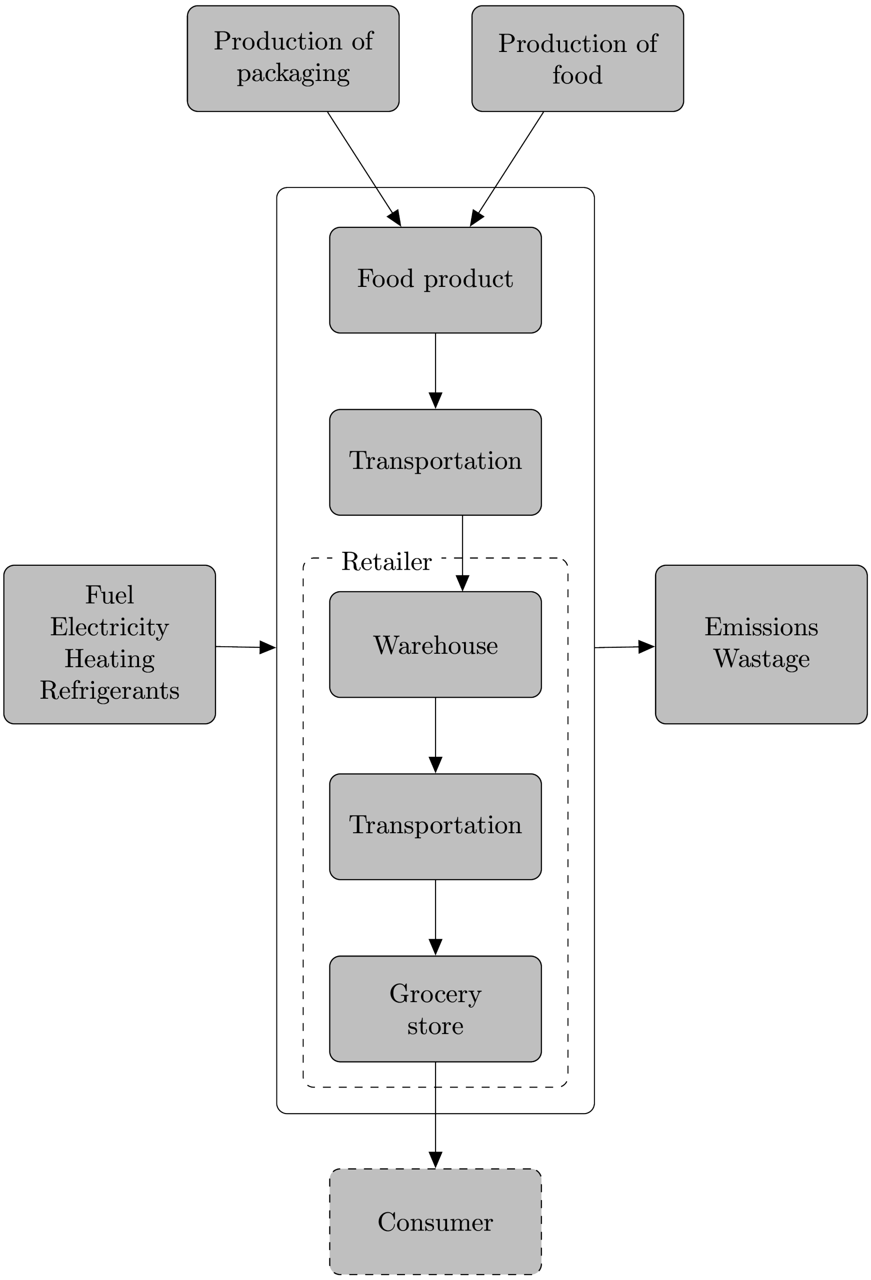

Figure 5: A general flowchart of the food products life cycle, except for milk.

5.1 Retailer

This section present data and information of retailer activities and data affecting the retailers activities; starting with warehouse (5.1.1) and delivery to the retailer (5.1.2), continuing with electricity consumption (5.1.3), heating (5.1.4) and storage at the retailer (5.1.5). After that the turnover time (5.1.6), sales ratio (5.1.7) and wastage (5.1.8) are presented. Figure 6 shows the activities at the retailer that the study has focused on.

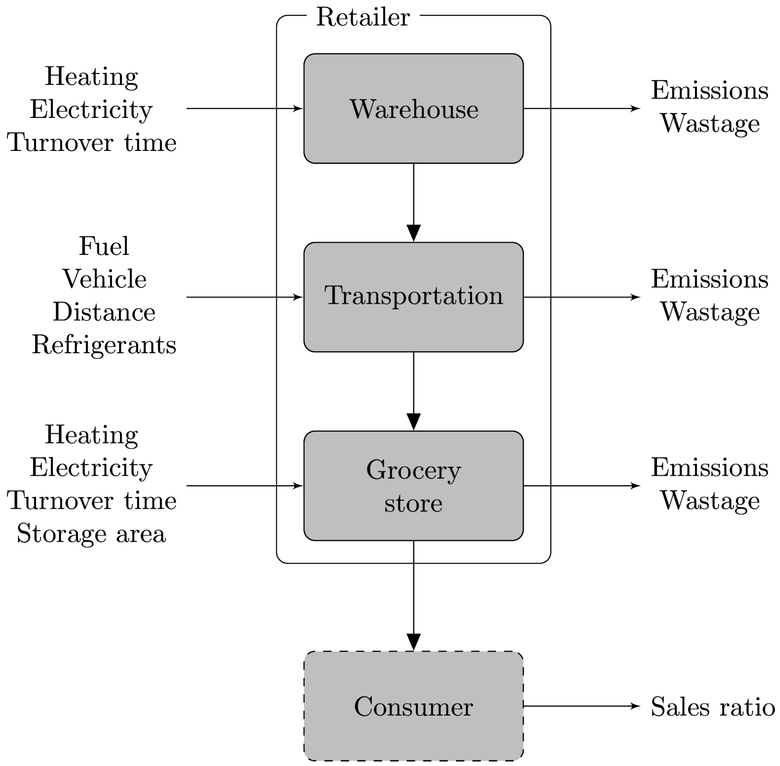

Figure 6: Retailer activities in the food products life cycle.

5.1.1 Warehouse

The product flow at the warehouse differs between the food products studied. Figure 5 demonstrate the flow of the product from a producer to the retailer; note that milk is transported directly from the producer to the retailer (Arla, 2015). Coop has three large warehouses with different characteristic in the middle of Sweden (Rosendahl, 2015):

Bro: Handles dry goods, such as flour, pasta, jam, napkins and non-food products.
Västerås: Handles refrigerated goods, such as: dairy products, fruit and vegetables.
Enköping: Handles frozen goods, such as: fish, vegetables and ice cream.

Table 6 summarize how long time the products are stored in Coops warehouse before it is transported to a retailer (Rosendahl, 2015).

Table 6: Summarize the time the studied food products are stored in one of Coops warehouses.

Product	Time in a Coop warehouse
Apple	Only redistribution
Banana	Only redistribution
Deep frozen cod	10 days (average)
Egg	Redistribution or maximum 1 day
Milk	-
Pork	5 days (average)

It is assumed that the products have the same storage environment as they have at the retailer, see 5.1.5.

5.1.2 Delivery

How frequently retailers receive deliveries of different food products vary due to the demand from customers (Schöld, 2015). The ordering of goods is mostly done semi-automatically; when a product gets sold this is noted in a computer system, the system keeps track on how much there is in stock and informs when it is time to purchase the product again. Since the computer system keeps track of how much that needs to be ordered it prevents the retailer to order too much groceries, and thereby less wastage is produced. This system works fairly well, reports Schöld (2015) store manager at Coop, except for products where consumers can pick as much as they want, such as fruit, vegetables and "Pick & Mix", in these cases the staff has to make own approximations of the demand.

Due to lack of information concerning how often retailers gets delivery of the different food products it will be assumed that the products are delivered in the same pace as their turn-over time estimated by Robertsson (2014), former sustainability manager, see table 7. It is assumed that conventional and organic products have the same delivery pattern.

Table 7: Estimated data on how often different products are delivered to the retailer.

Product	Deliveries per week	Deliveries per month
Apple	Twice a week	9
Banana	Twice a week	9
Deep frozen cod	Once a week	4
Egg	Twice a week	9
Milk	Every 2nd day	16
Pork	Once a week	4

5.1.3 Electricity consumption

Coops supermarkets have an average electricity consumption of 722 kWh/m^{2}year in the supermarkets (Kooperativa Förbundet, 2013). Previous studies have shown that food refrigeration stands for almost half of the retailers electricity consumption (Energimyndigheten, 2010). The same study also presents the distribution between other retailer activities that are in the need for electricity and how large share they have of the total consumption, e.g. food refrigeration 47 percent, lights 29 percent etc. By using the statistics from Energimyndigheten (2010) and Coops electricity consumption an estimation of Coops electricity distribution were calculated, see figure 7. Since apples, bananas and eggs does not need any refrigeration electricity for this part will be excluded from the calculation of their electricity consumption.

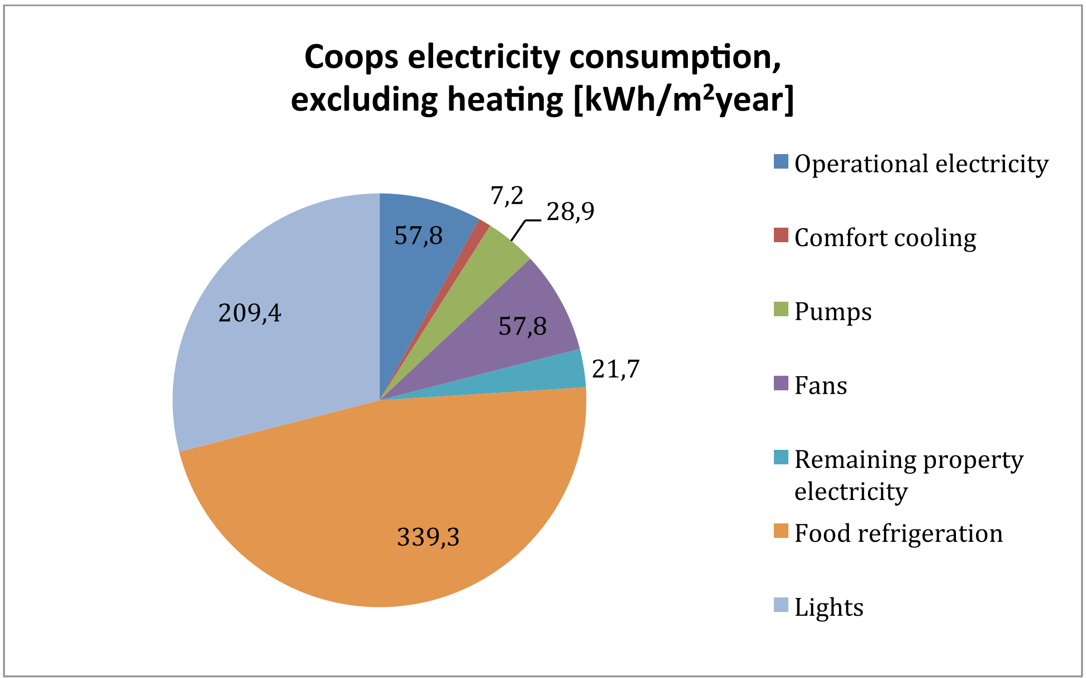

Figure 7: The distribution of Coops electricity consumption, excluding heating, according to Coops electricity consumption (Kooperativa Förbundet, 2013) and the general distribution of retailers electricity consumption compiled by Energimyndigheten (2010).

All of Coops grocery stores are certified according to KRAV. One of the obligations KRAV certified retailers have is to use electricity from renewable sources, with an exception for those retailers who can not choose there own distributor of electricity due to business leases (KRAV, 2015a). Coop has no guidelines on what type of renewable electricity that should be used, that is up to the owner of the grocery store (Robertsson, 2014). Electricity calculations will be made using electricity from a hydropower plant, since hydropower has the largest share in the Swedish market of renewable electricity (SCB, 2014).

5.1.4 Heating

Choice of heating system is, in similarity to electricity distribution, dependent on whether it is included in the retailers business leases, or the condition of to building, some retailers have, for example, installed solar collectors on the roof (Robertsson, 2014). District heating is the most dominate heating system used in commercial facilities in Sweden, with a specific use of 67 kWh/m^{2}year (Energimyndigheten, 2010). Since no specific data for Coops, nor general data concerning supermarkets heating have been found, the data for commercial properties will be used.

The district heating system in Gothenburg is based on the supply of district heat from several production facilities in the area (Göteborg Energi, 2015). Göteborg Energy offers two types of district heating; "conventional" and environmental labelled. The ghg emissions for producing 1 kWh of conventional district heating is 56 gCO_2-eqv/kg and environmental labelled district heating is 13 gCO_2-eqv/kg (Göteborg Energi, 2014a, Göteborg Energi, 2014b). The calculations in this LCA will be made with the value for environmental labelled district heating.

5.1.5 Storage at retailer

Data of the storage area and type of storage for the studied food products at the grocery store were collected by visiting four Coop stores in Gothenburg. In the store packaging of one kg of the food product and the size of the storage area were measured. The collected data for the total storage area of the food products from each grocery store were recalculated to an average storage area for each food product at the supermarket. The results are summarized in table 8. Note that conventional bananas only were sold in two of the four investigated grocery stores.

Table 8: Type of storage and average storage area (m^2) associated with one kg of the food product and the total storage area for the conventional and the organic food product.

Product	Type of storage	Storage area 1kg product	Average storage area conventional	Average storage area organic
Apple	Open shelf	0,021 m^2	4,00 m^2	0,83 m^2
Banana	Open shelf	0,019 m^2	0,65 m^2	0,73 m^2
Deep frozen cod	Deep-freezer	0,016 m^2	-	1,78 m^2
Egg	Open shelf	0,054 m^2	1,31 m^2	0,85 m^2
Milk	Refrigerator	0,0049 m^2		0,32 m^2
Pork	Refrigerator	0,032 m^2	1,20 m^2	0,33 m^2

Carlson and Sonesson (2000) have performed a life cycle inventory of three ICA retailers in Sweden in order to study which methods that should be used when calculating a products environmental impact at the retailer. They recommend that allocation due to exposure is most preferable when calculating product impact, and therefore exposure allocation will be used. Calculations of the food products energy use at the retailer store have been made according to equation 3 below:

$$Energy\ use\ per\ product = Energy\ consumption \cdot Storage\ area \cdot Turnover\ time$$

Energy consumption [kWh/m^2h] – The retailers energy consumption, excluding heating and refrigeration[1]
Storage area [m^2] – The storage area occupied by the product
Turnover time [h] – The products turnover time
Energy use per product [kWh/f.u] – The energy allocated to f.u.

[1] This equation only includes operating electricity, heating and electricity use for refrigeration is thereafter added to the calculations.

In this study three food products; milk, pork and cod, are in the need of refrigerated storage at the retailer. Since no specific Coop data for the type of refrigerator and its electricity consumption has been found data from Carlson and Sonesson (2000) will be used. Carlson and Sonesson (2000) have made calculations of the retailers electricity consumption for milk (refrigeration) and French fried potatoes (deep-freezer). For milk the refrigeration data will be used as it presented. For pork calculation data for milk will be used, and the value is multiplied with 2,3 since pork has a longer turnover time than milk, see section 5.1.6. It is assumed that French fried potatoes and deep-frozen cod have the same energy use. The calculation data are presented in table 9.

Table 9: Energy consumption for refrigerated storage for 1kg of milk and 1kg of French fried potatoes (Carlson and Sonesson, 2000) that is be adapted for this study.

	Refrigeration	Freezer	Unit
Dairy storage	2,11E-04		kWh/kg
"Freezer" storage		4,13E-03	
Refrigerator/deep-freezer	7,23E-03	8,70E-01	kWh/kg

5.1.6 Turnover time

The turnover time varies a lot between different products. It mostly depends on how popular the product is, but it can also depend on how long durability the product has. During Mikael Robertsson (2014), former sustainability manager, interview he made estimations of the turnover time for the selected food products, see table 10.

Table 10: Estimated turnover time for the studied food products (Robertsson, 2014).

Product	Turnover time	Average time (h) at retailer
Apple	5-7 days	144
Banana	2-3days	60
Deep frozen cod	1-2 weeks	252
Egg	2-3days	60
Milk	1-2days	36
Pork	Maximum of 7days	84

5.1.7 Sales ratio

Coop (2014b) announced in a press release in September 2014 that sales of organic products continues to increase. They also informs that baby food tops the lists of products that most often is bought organic (≈30%), followed by egg on second place (28%), oil/vinegar (23%) on third place and fruit and berries on fourth place (22%). Coops sales of organic bananas have increased form 22 percent in the beginning of 2013 to 40 percent in late 2014 (KRAV, 2014c). No Coop specific data for milk and pork has been found, instead statistics form SCB (2014) informing about the general Swedish sales of these products have been used. Data that are applicable for the food products relevant for this study are presented in table 11.

Table 11: Sales ratio of conventional and organic food products as part of the total sales.

Product	Conventional	Organic
Apple	85,5%	14,5%
Banana	60%	40%[1]
Deep frozen cod	-	100%[2]
Egg	72%	28%[3]
Milk	87%	13%[4]
Pork	98,5%	1,5%[4]

1. **Source: KRAV (2014c)**
2. **Based on a Coop policy specifying that only MSC, ASC and Krav labelled fish are allowed to be sold at Coop (Coop, 2015b)**
3. **Source: Coop (2014b)**
4. **Source: SCB**

An activity that affects the sales ratio of the products is campaigns and reduced prices of products. Coop has successfully implemented the concept "the organic product of the week", which implies that selection of organic products have a price discount between 20-50 percent during one week (Coop, 2015c). This has result in increase sales of the selected organic products during that week. Regarding the special offer of organic fruit and vegetable Coop has noticed an increase of several of hundred percent (Coop, 2014b).

5.1.8 Wastage

Coop (2013) presents in their sustainability report for 2013 that the wastage (measured in physical destruction of food and other goods) to 2,06 percent. The aim for this study was, however, to find wastage data for the different food products and also, if possible, to find if there was any differences between the wastage rate from conventional and organic products.

During the interviews with M. Robertsson, former sustainability manager at Coop, and A. Schöld, store manager at Coop, a question about wastage ratio for the studied food products was asked. Both declared that they did not have any specific wastage rate on the different products and especially no data on potential differences between the conventional and organic food products. Robertsson (2014) informed, though, that it is usually more expensive for the retailer to purchase organic products so wastage of organic products are more expensive for the retailer, it is therefore likely that the retailer are more cautious when buying organic products.

Several studies, e.g. Gustavsson (2010) and (Eriksson and Strid, 2011), have addressed the amount of wastage that is generated by different food products at a retailer. However, only one study, concerning bananas, addresses the difference between organic (1,1%) and conventional (2,0%) wastage (Eriksson and Strid, 2011). Since there is a lack of information regarding the difference of wastage generated by conventional and organic food products, other than bananas, it has been assumed that the amount of wastage is the same, regardless of the production method, see table 12.

Table 12: The amount of wastage the food products generates at the retailer.

Products	Conventional	Organic
Apple	1,1 %[1]	1,1 %[1]
Banana	2,0 %[2]	1,1 %[2]
Deep frozen cod	-	0,36 %[3]
Egg	0,36 %[3]	0,36 %[3]
Milk	0,36 %[1]	0,36 %[1]
Pork	1,31 %[1]	1,31 %[1]

1. **Source: Gustavsson (2010)**
2. **Source: Eriksson and Strid (2011)**
3. **Estimations**

No specific wastage data have been found on egg or deep frozen cod. In an internal document, regarding an LCA of eggs and pork, provided by Birgit Brunklaus it has been assumed that eggs has the same wastage percentage as dairy (SIK, 2012). It will, for that reason, be assumed that egg has the same wastage rate as milk. According to Robertsson (2014), former sustainability manager, is the wastage of cod quite low. It has therefore been assumed that deep frozen cod has a wastage rat of 0,36%.

5.2 Food production

In this section LCA background data of the food products included in the study are presented. The aim has been to find as accurate data as possible, both in terms of production country and production year.

5.2.1 Apple

Swedish produced apples have approximately 20 percent of the market share, the rest of the apples are imported (Jordbruksverket, 2014). Where the apple originates from varies depending on the seasons, the main foreign suppliers of apples are Italy (27%) or the Netherlands (25%), and also long-range countries such as Argentina (8). The organic apples sold in Sweden are mainly imported from Italy (EkoMatCentrum, 2012).

Sessa et al. (2014) have performed an LCA of conventional Italian apples; processes included in the LCA are agricultural production, storage, processing and distribution. The nursery phase was not included, Sessa et al. (2014) assumed that this phase is negligible since the duration of the orchard can exceed 25 years. A study of Swedish apples greenhouse gas emission has shown that the organic apple production (incl. cultivation, storage and manure) release 38,5% less greenhouse gases compare to the conventional production (incl. cultivation, storage and fertiliser production) (Davis et al., 2011). The authors conclude that a reason to the large difference was that the conventional farm in the study used electricity for the cold storage and that this energy consumption should not be ascribed the production way itself but rather the size of the apple farm.

5.2.2 Banana

Latin America and Caribbean stands for 80 percent of the global export of bananas (Food and Agriculture Organization of the United Nations, 2014). Costa Rica (23%) and Panama (17%) are, according to (Jordbruksverket, 2014), the largest importers of bananas to Sweden. Since these are neighbouring countries the transport distance will not differ noticeably, it will therefore be assumed that all of the conventional bananas sold at Coop are imported from Costa Rica. For organic bananas the Dominican Republic is the largest exporter EU and Sweden (Food and Agriculture Organization of the United Nations, 2014), and it will therefore be assumed that the organic bananas are imported from the Dominican Republic.

Production data for bananas have been collected from the database Ecoinvent, *Banana production* (Ecoinvent, 2010). The dataset include information of the maintenance of the orchards after harvest of previous crop and ends with harvest and storage. Data regarding infrastructure, processing, packaging, overseas transportation and ripening are collected from (Svanes and Aronsson, 2013). This data only include the emissions of ghg. Refrigeration during transportation and waste handling is not included. After the storage the bananas are transported to Europe with a refrigerated ship over the Atlantic and is assumed to dock in Hamburg, Germany. There after it is transported with truck to Malmö where it is reloaded to the Coop train to Bro and thereafter transported to the warehouse in Västerås where the bananas are reloaded and transported to the retailer.

No study covering all of the impact categories for this study have been found. In a study by Roibás et al. (2014) its concluded that the organic banana production has 20 percent lower GWP than the studied conventional banana production. The study also shows that there are significant difference between the fertilizers and pesticides used in the different systems.

5.2.3 Deep frozen cod

Coop (2015b) has the ambition of only selling MSC or KRAV-labelled fishes, and therefore the collection of cod production data have been concentrated to the organic option. In 2008 86 percent of the cod imported to Sweden origin from Norway, followed by 14 percent from Denmark (KRAV, 2010), this also conform with performed observations in Coop stores indicating that the cod comes form Barents Sea and northeast Atlantic.

KRAV (2010) conducted a study comparing greenhouse gas emissions from a KRAV-labelled cod block with an average cod block. Another study, made by Winther et al. (2009) study the carbon footprint and energy use of Norwegian seafood production. Both of these studies have focused on greenhouse gases, since no report studying other environmental impacts have been found the calculations for cod will focus on greenhouse gases. Since this study only focus on the "organic" option of cod data from KRAVs report will be used. A short information about the fish production is found in appendix C.

The global warming potential of KRAV-labelled cod is 1,4 kg CO_2-eqv. According to KRAVs study (2010) the greenhouse gas emissions from 1kg MSC produced hoki in New Zealand is 1,9 kg CO_2-eqv. The reason for the higher GWP, compared with KRAV cod, is that the transportation for the hoki is longer. The greenhouse gas emissions of fishing and processing the MSC hoki and the KRAV cod are almost the same.

5.2.4 Egg

Swedish egg production generates around 100 000 ton eggs/year, which corresponds to a degree of self-sufficiency of 87 percent (Jordbruksverket, 2011a). It is therefore most likely that eggs bought in a Coop store are produced in Sweden.

Data of egg production system have been collected from two reports by SIK, one that includes data for conventional eggs (Sonesson, 2008) and another for organic egg production (Carlsson, 2009). The included production steps for eggs are: breeding of hens for hatching, feed production, the farm, the production of packaging, packing of eggs, slaughterhouse, waste handling, transportation and retailer. A short explanation of the two systems is presented in appendix C.

5.2.5 Milk

The vast majority (around 90%) of the milk sold in Sweden also has Sweden as country of origin, even if the import of milk has increased in recent years (Jordbruksverket, 2012). In 2004 Cederberg and Flysjö performed an LCA of Swedish dairy farms located in the south of Sweden. A similar report on dairy farms in the north of Sweden were performed by Cederberg et al. in 2007. The two studies have similar approaches and system boundaries. For the background system in this study the LCA of dairy farms located in the south of Sweden will primarily be used. This is due to the fact that the milk will be sold in Gothenburg and it is more likely that the milk is produced in this region. Since Cederberg and Flysjö (2004) does not include information about energy consumption this part will be gathered from the study in northern Sweden.

5.2.6 Pork

The Swedish self-sufficient ratio of pork has been reduced during the last 15 years, nevertheless Swedish pork still has a self-sufficient ratio of 76 percent (Jordbruksverket, 2011b). Since the production of organic and conventional pork in Sweden differs a summary of the systems will be presented in appendix C.

After the search for conducted LCA of pork production it can be stated that most of the previous studies have focused on greenhouse gases. Carlsson et al. (2009) have, however, performed a study on organic pork production in Sweden studying GWP, AP, EP, energy and land use. The study is based on data from one pig farm, so the result should be interpreted cautiously, it can, however, give an indication of the environmental impacts of the production. Sonesson et al. (2009) have compiled an inventory over conducted LCAs of pork production in Sweden. In the report they present a summary of greenhouse gas emissions and energy use.

5.3 Transportation

The mean of transportation varies depending of the amount of products that are transported, distance and type of food product. Coop has no trucks for distributing food products between the warehouse and the retailer; instead Coop purchases transport solutions from external parts regarding both truck and train transportation. One of the requirements Coop has on the transport companies is that all vehicles that drive on behalf of them should be driven on diesel with "environmental class 1". Two types of trucks will be included in this study, see table 13.

Table 13: Fuel consumption (l/tkm) for a heavy truck (Hammarström and Yahya, 2000).

	Short distance	Long distance	Unit
Truck <16ton	0,150	0,109	l/tkm
Truck >16ton	0,0964	0,0553	l/tkm

The fuel consumption of a heavy truck can vary considerably depending on the load factor, therefore is the concept of l/km not preferable when discussing a trucks fuel consumption (Trafikverket, 2014). In order to include the load in the fuel consumption concept [l/tkm] can be used, i.e. how much fuel that is needed to transport one ton per kilometre. Equations for calculating the fuel consumption are found in appendix D.

For this LCA adapted values from a study by Hammarström and Yahya (2000) will be used. In the study Hammarström and Yahya (2000) have presented their results according to when the production year of the truck, since the aim is to use as recent data as possible only the data for age class 1990-1998 will be used. They have also separated the fuel consumption between distances, short range (<100km) and long range (>100km), see table 14. The fuel consumption from the study is based on diesel, for the calculation it will be assumed that the consumption of diesel and RME is the same.

Table 14: Physical properties of fuels. Source: Hallberg et al. (2013e).

	Heat value [MJ/kg]	Density [kg/m^3]
Fossil diesel MK1	43,3	815
RME	38,0	833

The most common environmental classification on Swedish registered trucks in 2013 was Euro V the most common truck among the once registered in Sweden (Trafikanalys, 2014). Hence it will be assumed that the trucks have a EURO V classification. The transport distances have been estimated with the help of map tool Google maps. Documentation of distances, duration and transportation data can be found in appendix D.

5.3.1 Refrigeration during transportation

A large number of food products require refrigerated transportation. The refrigerating aggregate in trucks has an average diesel consumption on 3l/h, regardless of the cooling temperature (Winther et al., 2009). The most commonly used refrigerants are R134a and R404a (Nilsson and Lindberg, 2011). These refrigerants have, according to IPCC, a global warming potential of 1430 CO2-eq/kg refrigerant (R134a) and 3920 CO2-eq/kg refrigerant

(R404a). There are no data available on to which extent these refrigerants are used, it will therefore be assumed that they are used in equal amounts.

The volume of refrigerants in a truck is at average 6,5kg and the leakages of refrigerants are approximately 5-10 percent. Calculations performed by Winther et al. (2009) shows that the usage of refrigerants is equal to a diesel consumption of 0,3 l/h, regarding greenhouse gas emissions.

5.3.2 Wastage during transportation

Rosendahl (2015), transport manager at Coop, states that the wastage generated in the transportation chain is small, even though it can vary from product to product. It will be assumed that the wastage in a transportation is the same percentage as in the supermarket, see table 15.

Table 15: Assumed percentage of waste generated in each step of transportation (Rosendahl, 2015).

	Conventional	Organic
Apple	1,1 %	1,1 %
Banana	2,0 %	1,1 %
Deep frozen cod	-	0,36 %
Egg	0,36 %	0,36 %
Milk	0,36 %	0,36
Pork	1,31 %	1,31 %

5.4 Fuel production

As stated in 5.3 calculations on the fuel consumption will be performed with environmental data on diesel "environmental class 1". 76 percent of the diesel sold in Sweden 2008 were mixed with 5% FAME (fatty acid methyl ester). In Sweden a common FAME is RME (Gode et al., 2011). Due to this reasons data for diesel 5%RME will be used.

Data for diesel with 5% RME has been calculated with 95% of the diesel emissions and 5% of the RME emissions. In the production chain of diesel the following steps are included: extraction of the crude oil, transport to refining site, refining of fuel and distribution chain. The data for RME includes, energy consumption and emissions related to the production, which includes cultivation of rape, harvest, transportation to refining site, RME production and the usage in trucks (Hallberg et al., 2013e).

For fuel data the CPM LCA database has been used, table 16. For more details on inputs and outputs in the fuel production see appendix D. Buildings and infrastructure are not included in the fuel production data.

Table 16: Well-to-wheel data for 1MJ of fuel at the wheel.

	GWP [CO_2-eq.]	Acidification potential [SO_2-eq.]	Eutrophication potential [NO_3-eq.]	Total energy use [MJ]
Diesel 5% RME	7,81E-02	2,01E-04	3,86E-04	6,90E-02
Diesel	8,05E-02	1,99E-04	3,55E-04	5,76E-03
RME	3,11E-02	2,49E-04	9,73E-04	1,27E+00

6 Results

In this section a selection of the results for the life cycle impact assessment are presented. Results for all of the studied food products divided into impact categories are found in appendix E. Due to a variation in the level of detail in the background data for the studied food products it has been decided that when comparing the whole food chain only GWP will be used. It is however important to remember that to be able to perform a complete assessment of the food chains total environmental impact other impact categories also has to be studied. This result only affects climate change. Nevertheless, on retailer level both GWP, AP and EP will be presented.

Figure 8 compares GWP for all products included in the study, as well as for conventional and organic production. By presenting all products total GWP in the same figure its possible to study how their contribution to climate change are in relation to each other. The figure also visualise the attribution different activities have on the food products total GWP. Also included in the figure is "conventional" deep frozen cod. "Conventional" cod is, as previously mention, not sold in Coop grocery stores, the reason for including it in the result is to be able to compare this production method with KRAV-labelled cod. It also visualise the regulations effect on the retailers total GWP emissions (including both direct and indirect emissions).

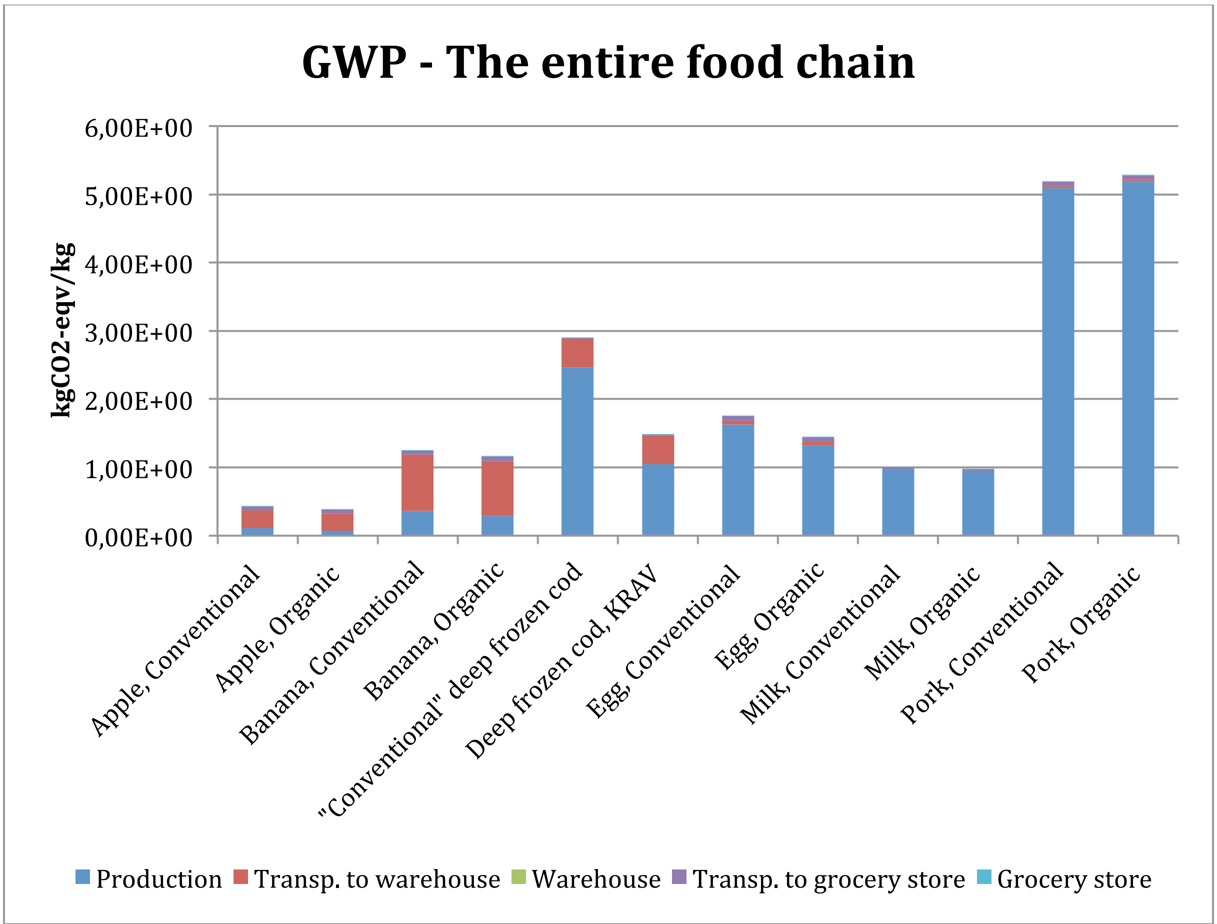

Figure 8: GWP for all activities included in the studied products food products life cycle. Both conventional and organic production is included.

Production of the food products has, in general, the highest contribution to the GWP. Products including animals, in one way or the other, have a higher contribution compared to the fruit studied. The retailers contribution to the total GWP of the food product is fairly low.

6.1 Retailer

Figure 9 illustrates the retailer activity associated with each food product. As displayed in the figure transportation has the highest contribution to emissions of greenhouse gases. The main reason why the transportation have different contribution to the products GWP is the transportation distance; shorter distance generates lower emissions. Milk is, for example, transported 145 km meanwhile cod is transported 408 km.

Products requiring refrigerated transportation have "use of refrigerants" as their second largest contributor to the GWP. The refrigerants stands for around 2–8 percent of the food products total GWP where the variation depends on the volume transported. In these calculations refrigerants only contribute to climate change, meanwhile the fuel needed for the refrigeration aggregate is included in AP and EP as well.

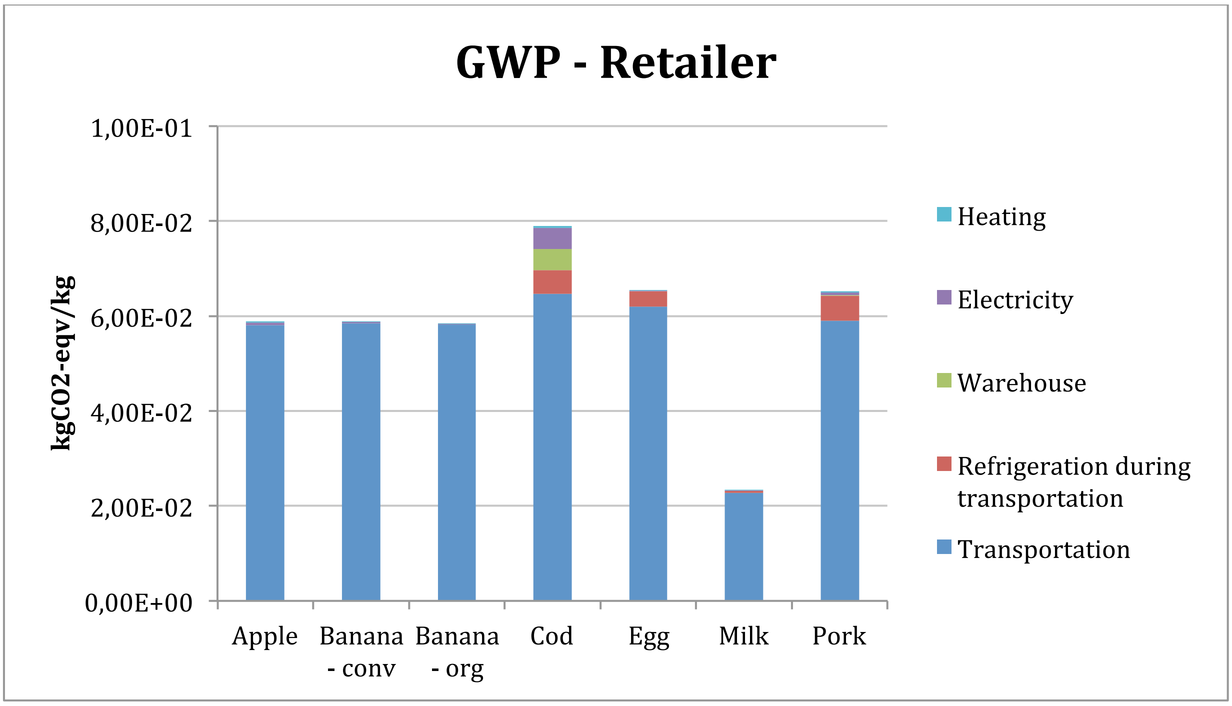

Figure 9: The retailers contribution to the food products GWP.

Figure 10 shows the AP of the retailer activities associated with the studied food products. Transportation has, equally to the retailers GWP, the greatest contribution to the retailers AP. The contribution on warehouse and operating electricity are only visible for cod and pork. A reason for that is that these products have a slightly longer turnover time compared to the other products, and also their need for refrigerated storage. Note that emissions regarding heating are not included in the AP since only data regarding ghg emission was found for heating.

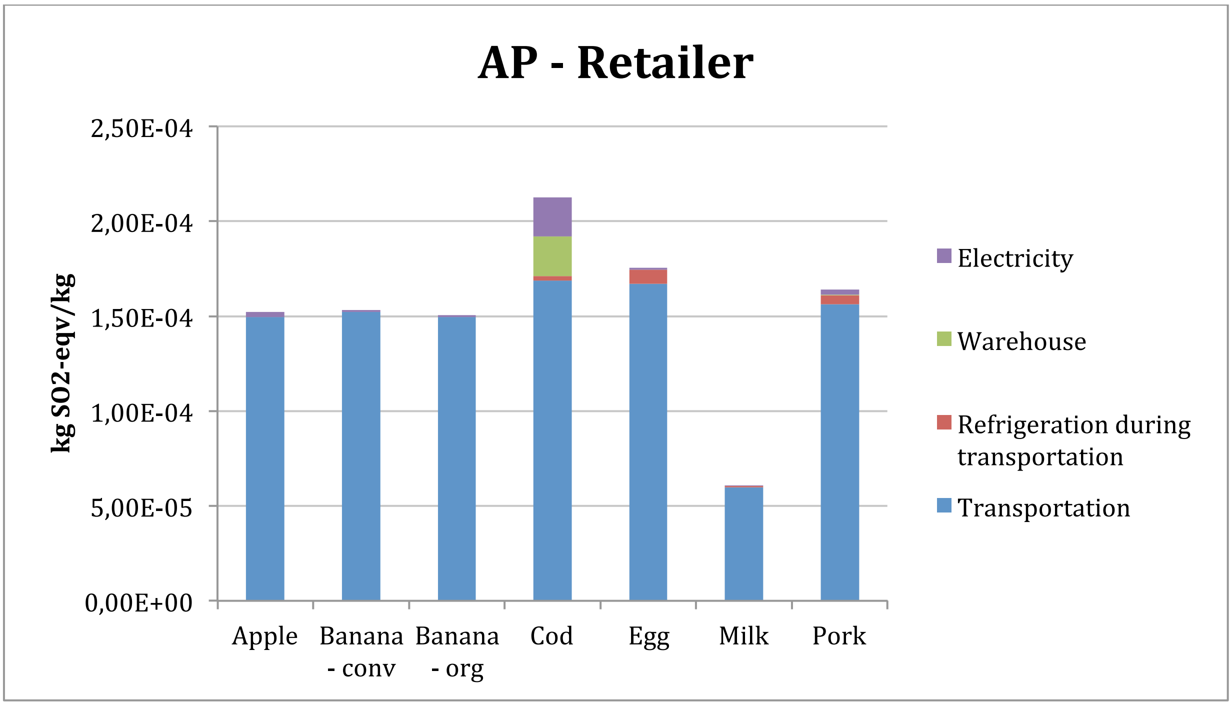

Figure 10: The retailers contribution to the food products AP. Note that no emission for heating is included.

In figure 11 the result for the retailers EP is presented. The EP related to the retailer activities associated with the studied food products follows the same pattern as for AP, where transportation is the main contributor of emissions affecting the EP. The retailers handling of cod contributes to the highest amount of EP, this is due to length of the turnover time. Note that emissions regarding heating are not included in the EP since only data regarding ghg emission was found for heating.

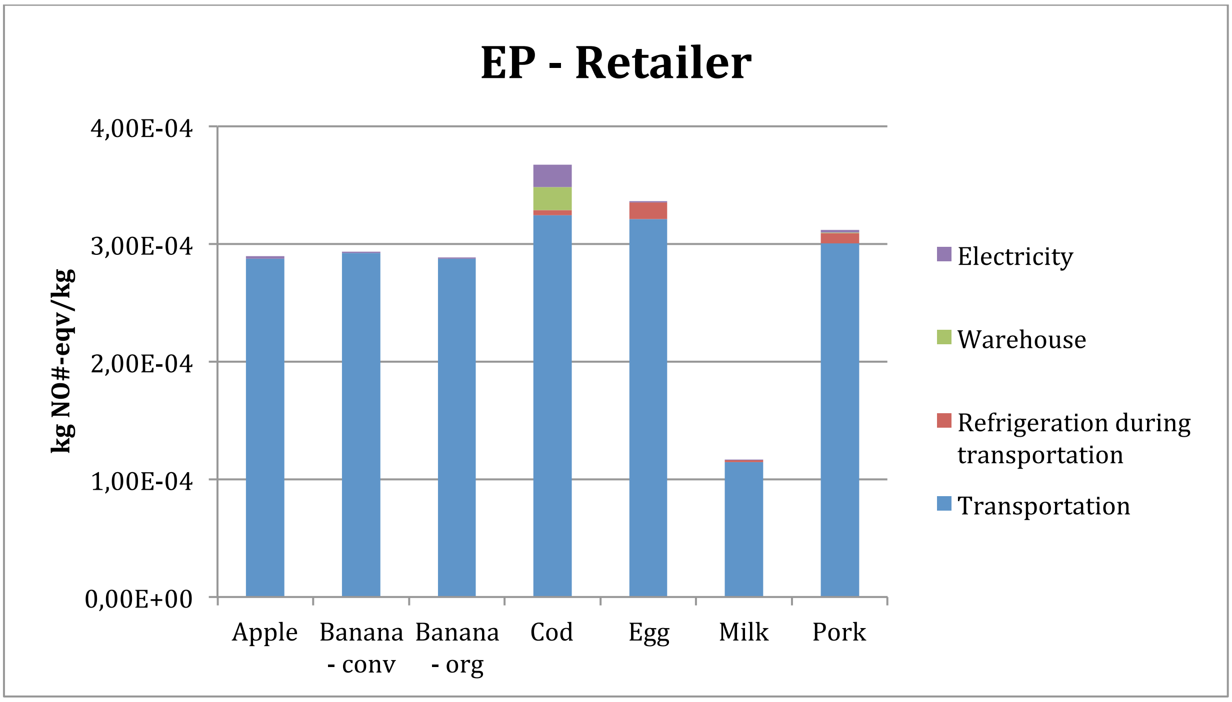

Figure 11: The retailers contribution to the food products EP. Note that no emission for heating is included.

In the result presented above the retailers transportation between warehouse and grocery store is included. The transportation between the producer and the warehouse have, however, been ascribed the food production, it can however be possible for the retailer to affect this transportation as well. This can be done with standards regarding transportation but also by producing their own food products so that the retailer have a insight in the whole production chain.

6.1.2 Wastage reduction

Banana was the only product where it was possible to find quantitative information, at a retailer level, that differs between conventional (2%) and organic (1,1%) produced products. The LCA shows that a reduction of wastage with 0,9 percentage points have a noticeable effect of the GWP, see figure 12. The total GWP reduction is 1,4 percent. Since the background data for conventional and organic bananas are the same it is possible to conclude that the difference in GWP is only due to the reduced amount of wastage.

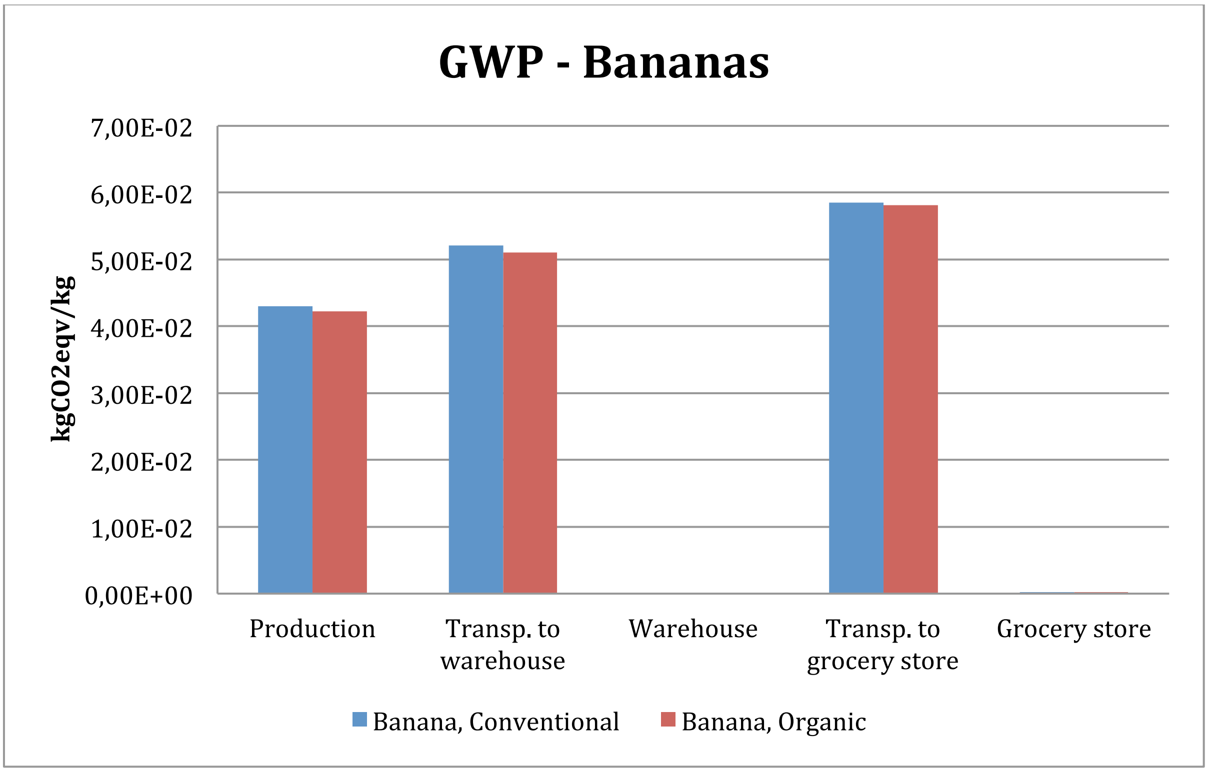

Figure 12: Difference in GWP for the different actors in the conventional and organic bananas life cycle. The change is due to less amount of wastage for organic bananas.

A similar pattern occurs for the bananas AP and EP, see figure 13. The decrease of AP is 16 percent, and this is mainly due to the reduction of emissions in the production step. For EP the reduction is 4,5 percent.

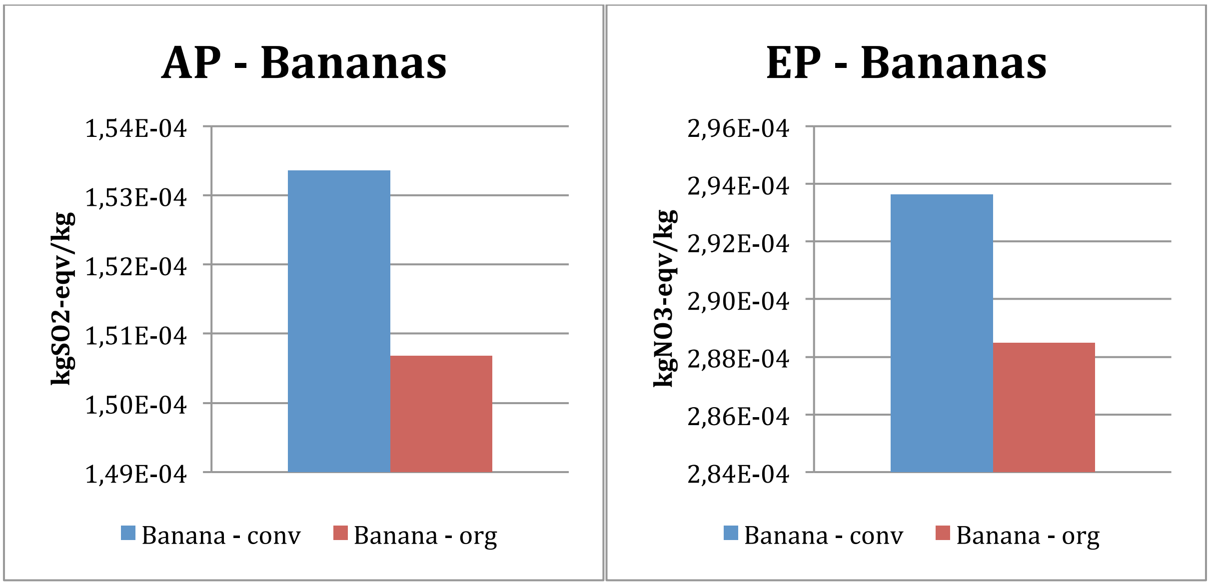

Figure 13: Difference in AP (16%) and EP (4,5%) for the whole production chain of conventional and organic bananas. The change is due to less amount of wastage for organic bananas.

6.2 Sensitivity analysis

The LCA shows that the retailers greatest environmental contribution is transportation of food products. For that reason a sensitivity analysis of the transportation were made regarding the choice of fuel. Figure 14 illustrates GWP, AP and EP for the transportation of apples from the warehouse to the supermarket with two different choice of fuel, diesel with 5% RME and pure RME.

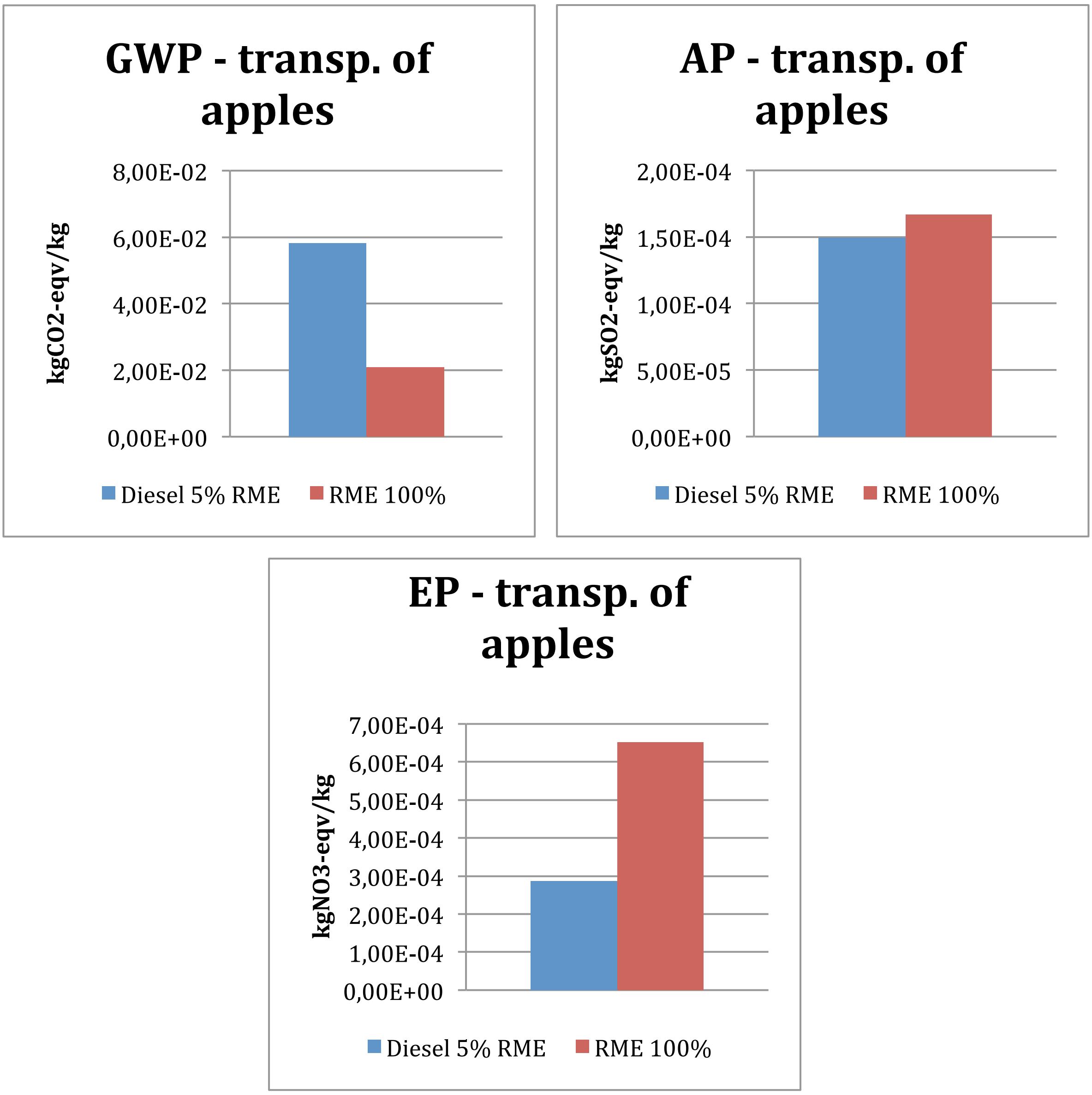

Figure 14: Three diagrams illustrating how a change from diesel 5% RME to RME 100% would affect the GWP (-40%), AP (+12%) and EP (+127%) for transporting apples from the warehouse to the supermarket.

A change from diesel 5% RME to RME 100% would reduce the emissions of greenhouse gases with nearly 40 percent. At the same time the emissions that contribute to AP would increase with about 12 percent and the emissions that contribute to EP would increase with about 127 percent. This is mostly due to increased emissions of NOx.

7 Discussion

In this study the environmental impact of Swedish retailers handling of food products, and more specifically Coops handling of products, were studied. In the beginning the study aimed for collecting site-specific data from Coops grocery store, internal procedures and observations. Unfortunately this was not possible and a change of method was made, resulting in more general Coop data gathered through interviews and literature review. A consequence of this is that the result has a more general approach than intended from the beginning; it does however give an indication of the retailers environmental impact on the food products studied.

7.1 Result analysis

The results from the LCAs indicate that throughout the food products life cycle the retailer has a small contribution to the environmental impact, regardless of the impact categories studied. Transportation is the retailer activity that contributes most to GWP, AP, EP and Energy; this applies for all the studied products. Choice of transportation vehicle affects the result of the emission as well as fuel and transportation distance. Coop has already established a system of transporting goods on train, if this proportion would increase a greater reduction of emissions would be accomplished.

Retailers second largest environmental impact varies depending on the food product studied and the impact category. Use of refrigerants is the second largest contributor to the retailers GWP. The refrigerants are used when transporting products that require cold space storage, such as deep frozen cod, egg, milk and pork, meanwhile products such as apples and bananas are in no need of refrigerants during the transportation. This result is in line with Coops own calculations of their climate impact showing that 61 percent of the emissions is due to transportation of goods and 21 percent is due to the usage of refrigerants. In terms of the retailers total GWP warehouse, operational electricity and heating have a fairly small contribution. Regarding AP and EP, both follows a similar pattern where transportation is the greatest contributor, followed by operational electricity and heating.

Another observation of the result is that the production of the food products has the greatest impact on climate change, acidification potential and eutrophication potential, except for bananas where transportation had the greatest contribution. This pattern is confirmed by Angervall et al. (2008) and Ingvarsson (2002) and is most likely due to production of fertilizers, livestock keeping, processing of the soil and pesticides. Transportation is the second largest contributor to food products GWP, AP and EP; meanwhile operating electricity and heating at the retailer is almost negligible in the food products life cycle.

The LCA does not give any indication of a difference between conventional and organic products at a retailer level, except for bananas. A reason for this is that very little information about if conventional and organic food products are handled at the retailer. For bananas a difference in wastage were found resulting in a lower environmental impact at the retailer level from the organic bananas. The reduction is a result of the fact that a lower amount of bananas need to be transported and stored to be able to sell one kg bananas. A reduction of wastage at the retailer level also affect the environmental impact of the banana, since fewer bananas need to be produced.

7.1.1 Handling of food products

What is not visible in the LCA is the quantitative data collected during the study. The sales ratio between conventional and organic products shows that conventional products are sold in greater quantities, the gap is however decreasing. A reason for that can be retailer campaigns of organic products, increased customer awareness and the food placement in the supermarket.

Coop has successfully performed the campaign "the organic product of the week" resulting in increased sales of organic products. The consumer has the willingness of purchasing organic products and when the price differences are reduced they take the opportunity of buying organic. An increase of organic products would affect the retailers environmental impact. As shown in the LCA organic products usually have a lower GWP but a higher AP and EP. There are however other important environmental impacts that are not covered by the LCA, such as usage of pesticides in the production, effect on human health and biodiversity. The reason for this is the limitation of LCA where not all parameters can be included; it is therefore necessary to also perform qualitative analysis where a wider range of environmental impacts can be taken into account.

The production of KRAV-labelled fish release 56 percent less greenhouse gases compared to "conventional" cod production. Coops policy regarding that only environmental labelled fishes are allowed to be sold in the supermarkets is a good way to put requirements on the producers to make the fish production chain more sustainable. Similar requirements could be imposed on other products and suppliers in order to push the development of the food supply chain in a more sustainable direction.

7.2 Sensitivity analysis

To estimate how sensitive the results are to changes in input data several sensitivity analyses were performed. Transportation is the retailers greatest environmental impact, mostly due to the fuel needed in the transportation, choice of transportation vehicle and distance. All trucks have been assumed to run on diesel with 5% RME, if Coop would switch to 100 percent biodiesel (e.g. RME) in their trucks the greenhouse gas emission would decrease with approximately 35–40 percent. Emissions of nitrates and sulphur dioxide, among others, would increase resulting in a higher AP and EP compared with diesel trucks.

The fuel consumption for the trucks used in the calculations is gathered from Hammarström and Yahya (2000). Reviewing studies regarding climate impact from transportation it seams likely that the fuel consumption has been reduced since the study by Hammarström and Yahya (2000) was conducted. Such a reduction would result in fewer emissions from the transportation and therefore a reduced GWP, AP and EP. It would therefore be advisable to recalculate the emissions due to transportation with data that is more up to date.

It was assumed that the retailers had electricity from hydropower, due to KRAVs regulation about renewable energy. If a retailer has a business leases for the grocery store it is not always possible for the retailer to decide their own electricity mix. Another electricity mix would most likely increase the emissions from electricity consumption since hydropower has a low environmental impact compared to many other common renewable sources.

7.3 Method analysis and data quality

When performing an LCA it is necessary to have quantitative data that can be used in the calculations to obtain the environmental impact of the studied product. Since this study also investigated how retailers manage their food products a qualitative approach was also taken. A questionnaire, which sought for information about the studied food products, was sent out to all store managers in Göteborg, the response was absent. After phoning a selection of the store managers it was concluded that requested information was not available for unauthorised persons.

Personal experiences from Coop employees were collected through interviews and email conversation. Three employees had the opportunity to answer the questions asked. In order to strengthen the study it would have been desirable to have a wider selection of Coop employees sharing their experiences. Another activity that would have strengthened the study is if it would have been possible to perform the study in collaboration with a Coop supermarket. That would have given valuable inside information concerning internal procedures and possibilities to observe employees in action to see how they actually handle different food products.

Because of time constraints in the study it was decided to collect production data of the investigated food products from already conducted LCAs. In the search for these LCAs aim was to find studies that had the same country of origin as stated in the geographical boundaries, this was possible for all food product except for organic apples and bananas. Despite this there are still uncertainties in the background system since the collection of data has not been collected from Coops own farmers and distributers. This, however, probably do not affect the result in any significant way since the production of food products has the greatest contribution to a food products environmental impact.

All products studied, except the deep frozen cod, have a fairly short turnover time at Coop, this is reflected in the LCA where the environmental contribution from electricity and heating are almost non-existent. Carlson and Sonesson (2000) concluded that products with long turnover time, e.g. pasta, can be ascribed a larger share of the electricity consumption regardless of storage environment. In a future study it would therefore be interesting to also include such a product.

7.4 Future research

Studies have shown that retailers environmental impact in a products life cycle is quite small. There is, however, a need for more studies about retailers impact in the food products life cycle, especially when it comes to retailers indirect environmental impact e.g. advertisements of sustainable products and choice of food producer.

There is also a need for more research regarding the retailers handling of food products. For example if there is a difference in how conventional and organic food products are handled and in what way this would affect the retailers environmental impact.

8 Conclusions

LCA can be used to investigate a products environmental impact. In order to understand the actors within the product life cycle an actor analysis can be performed. By collecting data, both qualitative and quantitative, a greater understanding for the actors environmental impact on the food products can be achieved. Following conclusions were drawn on the basis of the LCA and this study:

- Retailers greatest environmental impact, regardless of impact category studied, is transportation. When considering global warming potential usage of refrigerants during transportation is the second largest contributor. Warehouse, operational electricity and heating only contribute to between 1-20 percent regardless of impact category studied.

- Only minor differences in the retailers handling of conventional and organic food products have been found. It has been shown that organic bananas contribute to less wastage than conventional bananas which result in a reduction of emissions during the bananas life cycle.

- Retailer policies, campaigns and handling of food products can affect the retailers environmental impact both direct and indirect.

- The result of the LCAs shows that food production has the greatest contribution to the studied food products GWP, AP and EP. It also shows that production of animal based food products has a significantly higher GWP than vegetable based food products.

- Production of organic pork has the highest GWP of the studied food products followed by conventional pork production. Second highest GWP, with more than 50 percent less emissions, has conventional and organic egg production. Production of bananas has the lowest GWP.

- In future studies a greater collaboration with a retailer is preferable in order to receive internal documents and more retailer specific data, this could result in a better understanding of retailers handling of food products and their possibility to affect the food chain.

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Appendix A – KRAV regulation for retailers

In this appendix the KRAV regulations for retailers are presented. There are some general regulations that apply for everyone who has the certification and in chapter 14 the retail specific regulation is presented. The KRAV regulation is written in Swedish, and since the regulation is intended for Swedish retailers it has been decided not to translate it to English. The regulations are gathered from KRAVSs Regler, utgåva 2015.

1.7 Vilka delar i KRAVs regler berör mig

KRAVs regler innehåller dels allmänna regler, kapitel 2, 3 och 20 som berör alla oavsett produktionsinriktning, och regler som är anpassade till olika typer av produktion.

1.8 Definitioner

I KRAVs regler används följande begrepp.

2.1.2 Verksamhet som kräver KRAV-certifiering

Ditt företag ska vara certifierat i följande fall.

2.1.3 Verksamhet som inte behöver vara KRAV-certifierad

I följande fall behöver ditt företag inte vara certifierat.

2.1.4 Regelområden

KRAVs regler är dels allmänna, dels anpassade till olika typer av verksamhet. När du åtar dig att följa KRAVs regler gör du det för ett eller flera regelområden. De olika regelområden som finns för närvarande är.

2.1.8 KRAVs regler följer EU-förordning 834/2007

KRAVs regler är skrivna för att även uppfylla EUs förordningar om ekologisk produktion. Om reglerna i EUs förordningar är strängare än KRAVs regler så har förordningarna företräde.

3.4.1 Hygienarbete gäller hela företaget

Alla typer av hygieniska åtgärder omfattas, som exempelvis rengöring eller desinfektion av djurstallar, andra produktionslokaler, lokaler för växtodling inklusive växthus eller lokaler för förädlingsindustri. (EU)

3.4.6 Bekämpning i butik endast efter prövning

Efter prövning av certifieringsorganet kan bekämpning tillåtas i butik även då det finns KRAV-certifierade produkter kvar i lokalen. (EU)

3.7.2 Förnybar el

Den el som du köper in ska till 100 procent komma från förnybara energikällor, till exempel vattenkraft eller miljömärkt el.

3.7.5 Val av köldmedier i butik

När du som är certifierad för KRAVs butiksregler gör en nyinvestering i kylanläggningar ska du välja anläggningar med köldmedier som inte påverkar klimatet negativt. *Du ska till exempel inte välja HFC-föreningar.*

14 Butik

14.1 Butikens övergripande åtagande

Butiken ska locka kunder som söker KRAV-certifierade produkter att återkomma. Butiken ska göra det genom att:

14.1.1 Regler i andra kapitel som också gäller butik

Förutom reglerna i detta kapitel gäller KRAVs regler kring märkning i kapitel 20 och allmänna regler i kapitel 2 och 3. Observera speciellt följande punkter:

14.1.2 Minimikrav på sortiment

Butiken ska tillhandahålla och med tydlig skyltning exponera KRAV-certifierade produkter inom åtminstone följande produktkategorier om butiken har ett sortiment inom dessa kategorier.

14.1.5 Utbilda personalen

Personalen ska ha goda kunskaper om ekologisk produktion och om KRAV.

14.2 Hur du hanterar och säljer KRAV-produkter

Du kan sälja KRAV-certifierade produkter som är färdigförpackade, alltså förpackade av din producent eller leverantör, men du kan också sälja KRAV-certifierade produkter som är förpackade i butik, liksom omärkta produkter i lösvikt över disk eller för

14.2.2 Förädling och import

Om du förädlar (se definitioner) produkter i butiken ska du följa reglerna för förädlade KRAV-certifierade produkter i kapitel 9 som handlar om livsmedelsförädling.

14.2.5 Butiksförpackat

Du får packa och packa om KRAV-certifierade produkter. Hantera produkterna så att de inte blandas samman med eller kontamineras av produkter som inte är KRAV-certifierade.

14.3 Märkning, skyltning och exponering

Skyltning och märkning är till för att det ska vara lätt att hitta KRAV-certifierade produkter. Här finns de särskilda regler som gäller för KRAV-anslutna butiker. I kapitel 20 finns regler för märkning som gäller alla KRAV-anslutna företag.

14.3.2 Skyltning

Kunden ska tydligt se att butiken är KRAV-certifierad genom att skylt eller certifikat är väl exponerade i anslutning till entrén.

14.3.3 Informationsplats

14.4 Dokumentation

Du ska ha dokumentation som visar att du uppfyller KRAVs regler. Du ska kunna visa dokumentationen för ditt certifieringsorgan.

14.7 Förnybar el

Den el som används ska till 100 procent komma från förnybara energikällor, till exempel miljömärkt el. Detta gäller vid nytecknande av elavtal dock senast tre år efter inträde i certifieringen.

18.4.10 Kunskapskrav på revisorer inom livsmedelsförädling, fodertillverkning, butik samt restauranger och storhushåll

Revisorn ska ha genomgått en utbildning i HACCP (Hazard Analysis and Critical Control Points) och grundläggande livsmedelshygien för att få utföra en kontroll enligt KRAVs regler för Livsmedelsförädling, Slakt, Fodertillverkning, Butik, Restauranger oc

19 Certifiering av kedjor

Verksamheter som exempelvis butiks-, restaurang- eller hotellkedjor kan ha många verksamhetsplatser som är likartade och har en gemensam styrning.

19.1.1 Vilka kan kedjecertifieras?

Om ni är en grupp av verksamhetsplatser och har en gemensam styrning för att kontrollera att reglerna följs och har en gemensam ekonomisk redovisning, kan ni överväga om kedjecertifiering är ett bättre alternativ för er än enskild certifiering av verks

19.2 Kedjan ska ha gemensam redovisning och dokumentation

Ditt certifieringsorgan ska kunna analysera balansen mellan köpta och försålda volymer utan att behöva besöka varje verksamhetsplats. Det är särskilt viktigt att tänka på när det gäller hantering av varor i lösvikt i butik.

19.2.1 Inköp och försäljning ska kunna följas

I kedjans gemensamma redovisningssystem ska det gå att följa:

20.2.10 Hur den som inte är KRAV-certifierad får använda KRAVs märke

Den som inte är KRAV-certifierad får enbart använda KRAV-märket i mycket begränsad omfattning. Köparna får inte vilseledas att tro att ett företag eller dess produkter är KRAV-certifierade när det inte är så.

20.5.1 Vid hantering av obrutna förpackningar

Butiker, grossister och liknande som hanterar KRAV-märkta produkter i obrutna förpackningar får använda KRAVs namn på kvitton, följesedlar, fakturor, sortimentskataloger, sortimentslistor och liknande utan att vara certifierade enligt KRAVs regler.

Appendix B – Interview guide and questionnaire

The interview guide prepared for the interview with Mikael Robertsson, former sustainability manager at Coop. Before the interview no questions about bananas and deep frozen cod hade been prepared, this was evolved during the interview. The questions for bananas and deep frozen cod are similar to the questions regarding the other food products. The questionnaire is presented after the interview guied.

Introduction

1. Briefly about me
2. The purpose of the interview

Background information

3. What was your position/role at Coop?
4. For how long did you work at Coop?
5. When did you quite?

Purchases

6. How does Coops view on environmental questions affect purchasing patterns?
7. Does Coop have a policy regarding purchasing different products and services?
8. How the does supply chain look like?
9. Are there any differences between organic and conventional products?
10. How much opportunity has the stores to influence what they purchase? Locally produced?
11. In your opinion; how large are Coops possibilities to influence the suppliers (packaging, transportation)?
12. What are the requirements for products purchased by Coop?
13. What information about environmental impacts is required from the producers?
14. How does the consumers demands affect the purchasing?

Introduktion

1. Kort om mig
2. Syftet med intervju

Bakgrundsfrågor

3. Vad var din roll/arbetsuppgifter Coop?
4. Hur länge arbetade du på Coop?
5. När slutade du?

Inköp

6. Hur påverkas inköpsfunktionen av företagets syn på miljöfrågor?
7. Finns det någon policy i samband med inköp av olika produkter och tjänster?
8. Hur ser inköpskedjan ut?
9. Finns det någon skillnad mellan ekologiska och konventionella produkter?
10. Hur stor valmöjlighet har butikerna att påverka inköpen? Närproducerat?
11. Hur stor möjlighet anser du att Coop har att påverka sina leverantörer (förpackning, transportsätt)?
12. Vilka krav ställs på de produkter som köps in?
13. Vilka krav på information ställs på producenterna när det gäller miljöpåverkansfaktorer?
14. Hur påverkar kundernas krav inköpen?

Handling of products

15. Do you feel that there is any difference in handling organic/conventional products?

Storage

16. How many warehouses does Coop have?
17. Does the goods get delivered to the retailer from the nearest warehouse?
18. Are refrigerators/freezers covered?
19. How do you believe have the greatest opportunity to influence when it comes to a products production and delivery (from an environmental point of view)

Transportation

20. Which means of transportation are used?
21. How does the routes look like?
22. Distance (km)?
23. How does Coop think when it comes to co-packing? From supplier? From warehouse?
24. What degree of compaction does the transportation has?

Milk

25. How much milk is purchased?
26. What is the turn over time of milk?
27. What percentage is organic? (%)
28. How is the milk stored at the retailer? Warehouse?

Pork

29. How much pork is purchased?
30. What is the turn over time of pork?
31. How much pork is store cut?
32. What percentage is organic? (%)
33. How is the pork stored at the retailer? Warehouse?
34. How much of the pork is frozen? (%)

Hantering av produkter

15. Anser du att det finns någon skillnad i hanteringen av ekologisk/konventionella varor?

Lagring

16. Hur många centrallager har Coop?
17.
18. Levereras varor från det närmaste centrallager till återförsäljaren?
19. Är kylar/frysar täckta?
20. Vem tycker du har möjlighet att påverka mest när det kommer till en produkts produktions- och levereringssätt (ur miljösynpunkt)?

Transport

21. Vilka transportmedel används?
22. Vilken rutt?
23. Avstånd (km)
24. Hur tänker Coop kring sampackning? Från leverantör? Från centrallager?
25. Vilken packningsgrad har transporten?

Mjölk

26. Hur mycket mjölk köps in?
27. Vad är omsättningstiden på mjölk?
28. Hur stor andel är ekologisk? (%)
29. Hur förvaras mjölk, i butik? Lager?

Fläsk

30. Hur mycket mjölk köps in?
31. Vad är omsättningstiden på fläsk?
32. Hur mycket fläsk butiksstyckas?
33. Hur stor andel är ekologisk? (%)
34. Hur förvaras fläsket, i butik? Lager?
35. Hur mycket av produkterna fryses in? (%)

Egg

36. How much eggs are purchased?
37. What is the turn over time of eggs?
38. What percentage is organic? (%)
39. How are the eggs stored at the retailer? Warehouse?

Apples

40. How much apples are purchased?
41. What is the turn over time of apples?
42. What percentage is organic? (%)
43. How are the apples stored at the retailer? Warehouse?
44. What proportion of the apples sold at the retailer has Swedish origin? (%)

Wastage

45. What type of waste does a retailer generates?
46. How much wastage if generated by the above mention food products?
47. What work does Coop do to reduce the wastage?

Energy

48. What energy mix does Coop has? (wind/water/etc)

Ägg

49. Hur mycket ägg köps in?
50. Vad är omsättningstiden på ägg?
51. Hur stor andel är ekologisk?
52. Hur förvaras äggen, i butik? Lager?

Äpplen

53. Hur mycket äpplen köps in?
54. Vad är omsättningstiden på äpplen?
55. Hur stor andel är ekologisk? (%)
56. Hur förvaras äpplen, i butik? Lager?
57. Hur stor andel av de äpplen som säljs är svenska? (%)

Avfall

58. Vilken typ av avfall har Coop?
59. Hur mycket genereras av ovanstående produkter?
60. Hur arbetar Coop för att minska avfallet?

Energi

61. Vad har Coop för energimix? (vind/vatten/etc)

Questionnaire

In the section below are the questions that were sent out in a questionnaire the store managers at Coops grocery stores in Gothenburg. The questions were asked in Swedish and the food products asked for in the questionnaire are the one included in this study; apples, bananas, deep frozen cod, eggs, milk and pork.

Butiken

1. Namn på butiken
2. Hur stor säljyta har butiken?
3. Hur stor lageryta har butiken?

Inköp

1. Hur stor andel, i förhållande till antal varor, av den totala försäljningen är ekologiska respektive konventionella varor?
2. Hur mycket varor (på ett ungefär) köps in under en månad?
3. Hur mycket köper ni in av nedanstående produkter under en månad?
4. Hur stor del av inköpen av följande produkter är ekologisk?
5. Hur lång tid tar det från att en vara kommer in till butiken tills att den säljs (omsättningstid)?
6. Finns det, enligt dig, någon skillnad i butikshanteringen av ekologiska och konventionella varor? Om ja, hur?

Leverans

1. Hur ofta får ni leveranser av följande varor?
2. Från vilka länder kommer oftast dessa produkter?
3. Hur ser fördelningen ut mellan länderna (i %)?

Svinn

1. Hur mycket av det som köps in av respektive vara måste slängas, exempelvis p.g.a. utgånget datum eller trasig förpackning (d.v.s. svinn) under en månad?
2. Hur mycket svinn blir det totalt under en månad?
3. Påverkar eventuella krav på minsta tillåtna inköpsmängd den mängd svinn ni får i butiken? Om Ja, på vilket sätt?

Energi

1. Kan ni påverka butikens val av el?
2. Vad är butikens årsförbrukning av el?
3. Vilken energimix har butiken?

Uppvärmning

1. Kan ni påverka butikens val av uppvärmning?
2. Vad är butikens årsförbrukning för uppvärmning?
3. Hur värms butiken upp?

Övriga kommentarer

Appendix C – Specific information about the food products

In this section more in-depth information about the studied food products are presented.

Apple

Sessa et al. (2014) have performed an LCA of conventional Italian apples; processes included in the LCA are agricultural production, storage, processing and distribution. The nursery phase was not included, Sessa et al. (2014) assumed that this phase is negligible since the duration of the orchard can exceed 25 years. Table 17 present the environmental impact of one kg of conventional apples delivered at the retailer.

Table 17: Environmental impact of 1kg of conventional apples delivered at the retailer (Sessa et al., 2014).

	Cultivation	Processing	Packaging	Unit
Global warming potential	4,00E-02	6,00E-02	1,00E-02	kg CO_2-eqv
Acidification Potential	3,10E-04	2,20E-04	4,00E-05	kg SO_2-eqv
Eutrophication Potential	4,10E-04	8,00E-05	1,00E-05	kg PO_4-eqv

Table 17 shows the LCA data of Italian apple production, for this report GWP and AP will be used. The data for EP in Sessa et al. (2014) is expressed in PO_4-eqv but in this study EP is expressed in NO_3-eqv, EP for apples will for that reason not be included in this LCA. In the LCA Sessa et al. (2014) have calculated on an average distribution transport of 850km by truck and 250km with ship, this data will be recalculated for an transportation to Sweden.

Banana

Production data for bananas have been collected from the database Ecoinvent, *Banana production*, table 18 (Ecoinvent, 2010). The dataset include information of the maintenance of the orchards after harvest of previous crop and ends with harvest and storage. Data regarding infrastructure, processing, packaging, overseas transportation and ripening are collected from Svanes and Aronsson (2013), table 19. The production of organic bananas is assumed have 20 percent lower ghg emissions compared with conventional banana production, which is in line with Roibás et al. (2014).

Table 18: Environmental impact for producing 1kg of bananas (Ecoinvent, 2010).

Impact category	Quantity	Unit
GWP	0,19299	kg CO_2-eqv
AP	0,0012251	kg SO_2-eqv
EP	0,0014407	kg NOx-eqv

Table 19: The GWP for some processes included in the bananas product chain (Svanes and Aronsson, 2013).

Process	Quantity	Unit
Primary production infrastructure	0,0023	kg CO_2-eqv

Processing	0,017	kg CO_2-eqv
Packaging	0,08	kg CO_2-eqv
Transport to harbour	0,023	kg CO_2-eqv
Harbour storage and handling	0,016	kg CO_2-eqv
Overseas transport, pallet ships	0,75	kg CO_2-eqv
Harbour handling, Hamburg	0,017	kg CO_2-eqv
Ripening	0,008	kg CO_2-eqv

Deep frozen cod

The KRAV-labelled cod (KRAV, 2010) is caught using longlines in the Barents Sea and transported to Norway. During the transportation natural refrigerants such as carbon dioxide or ammonia is used, since KRAV regulation dose not accept conventional refrigerants. The climate impact from the fish processing in Norway is low since they have a hydro-based electricity production. After the fish has been processed it was assumed that the fish was transported to a warehouse in Helsingborg, Sweden. Coops warehouse for frozen products are located in Enköping, this will result in that the emissions of the transportation between Norway and Sweden will be slightly overestimated. Table 20 present the GWP for 1kg of KRAV-labelled cod.

Table 20: Global warming potential for 1kg of KRAV-labelled cod from Norway (KRAV, 2010). Includes: fishing, processing and transportation to Swedish warehouse.

	Diesel - fishing	Processing	Transportation	Unit
Global warming potential	9,5E-01	0,5E-01	4E-01	kg CO_2-eqv

Production of "conventional" deep fozen cod is assumed to be 2,35 kg CO_2-eqv.

Egg

The study of conventional eggs is based on data from two egg producers in Sweden. The first farm built the hen house in 2003. The hens are bought when they are 15 weeks old; they are kept for 64 weeks before they go to slaughter. The farm have 31 500 hens in total. During the 64 weeks the hen produces around 22,5kg eggs each. The farm delivers their eggs to Svenska Lantägg in Skara. Feed is bought from Svenska Foder, and consists mainly of gain and soybean meal. Manure generated by the hens are resold. The electricity consumption for the henhouse is 160 000kWh/year.

The second egg producer has both conventional and organic egg production on the farm; it is, however, only the conventional production that are included in this study. The henhouse was built in 2001, and can accommodate 12 560 hens. During the 58 weeks at the farm the hens produce approximately 20,2 kg eggs each. The farm delivers their eggs to Svenska Lantägg in Skara for future distribution. Feed is bought from Svenska Foder. Half the amount of manure generated by the hens is used at a crop production at the farm and the other half is sold. The electricity consumption for the henhouse is 72 000kWh/year.

The organic farm has, in conformity with the second conventional farm, production of both organic and conventional eggs. The farms henhouse was built in 1997, and in 2008 the house was rebuilding with two new floors with perches by the roof, the hens also have the possibility to be outside. The farm have 8 300 hens and during the 60 weeks at the farm the hen produces around 20kg eggs each. The farm delivers their eggs to Svenska Lantägg in Skara for future distribution. Feed is bought from Svenska Foder, and no fodder is produced at the farm.

In the calculations all transportation, wholesale, the retailer activity and electricity have been modified by data collected in this study.

Milk

The flowchart associated with milk I presented in figure 15.

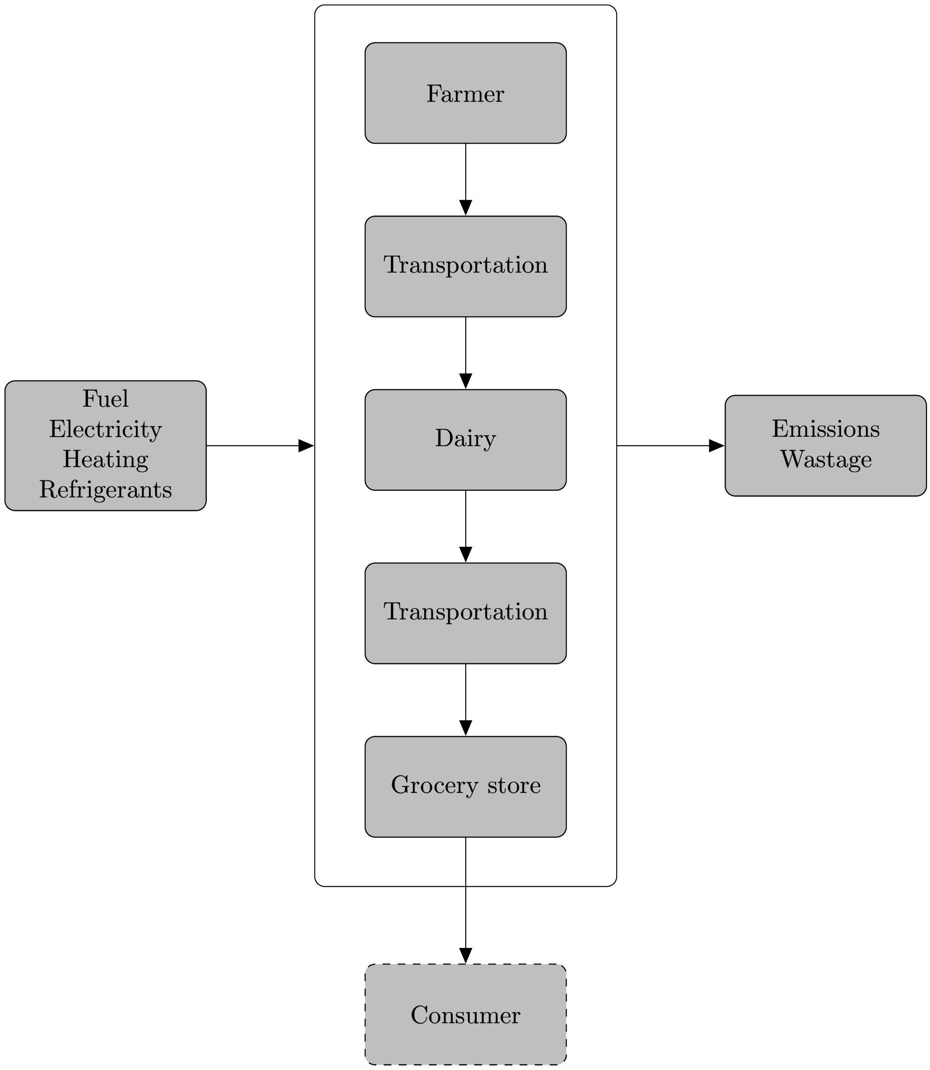

Figure 15: The flowchart associated with the life cycle of milk.

The LCA includes all phases in of milk production, extraction of raw materials, feed industry, energy use, cultivation and animals. The results are based on data from 17 conventional farms and 6 organic farms in Halland and Västra Götaland, Sweden. The functional unit was "one kg of energy-corrected milk (ECM) at the farm gate". In table 21 the environmental load for producing 1kg of energy-corrected milk is presented based on recalculated data from the LCA by Cederberg and Flysjö (2004).

Table 21: Environmental load for producing 1kg of milk energy-corrected milk. Recalculation made from data by Cederberg and Flysjö (2004).

		Conventional	Organic	Unit
Emissions	CO_2	1,71E-01	1,20E-01	kg
	CH_4	2,11E-02	2,29E-02	kg
	N_2O	1,15E-03	1,09E-03	kg
	NH_3	4,55E-03	5,63E-03	kg
	NOx	1,29E-03	1,07E-03	kg
	SO_2	5,91E-04	3,01E-04	kg
	NO_3 (water)	2,22E-02	2,89E-02	kg
	P (water)	9,84E-05	9,35E-05	kg
Resources	Phosphorus (P)	1,47E-03	6,87E-04	kg
	Potassium (K)	3,14E-03	2,84E-04	kg
Pesticide use		7,62E-05	7,83E-06	kg
Land use		1,73E+00	2,93E+00	m^2*year

Pork

The production of conventional pork is relatively uniformed in Sweden (Sonesson et al., 2009). Two different methods are used in the production; integrated and specialised rearing. In the first method the pigs are at the same producer from birth to slaughter. Meanwhile the second method has two actors, the first are breeding the pigs to around 20kg and there after they are sold to the second actor where the pigs are stationed until a weight of 110kg before they are slaughtered The breeding of pigs are, in both cases, done inside and the pigs are feed with grains and protein concentrate. Two differences between conventional and organic pork production are the opportunity for the pigs to be outside and the design of the piggery.

The environmental load of producing 1kg of boneless por at the frame-gat is presented in table 22.

Table 22: Environmental load of 1kg of boneless pork at the point of the farm-gate (Carlsson et al., 2009, Sonesson et al., 2009).

		Conventional	Organic	unit
Emissions	CO_2	1,37E+00[1]	1,70E+00[1]	kg CO_2-eqv
	CH_4	1,03E+00[1]	7,25E-01[1]	kg CO_2-eqv
	N_2O	2,33E+00[1]	2,40E+00[1]	kg CO_2-eqv
Acidification potential		-	1,20E-01[2]	kg SO_2-eqv
Eutrophication potential		-	4,95E-01[2]	kg NO_3-eqv
Pesticide use		8,50E-04[3]		kg
Land use		13,0[2]	32,0[2]	m^2*year
Secondary energy		22,5[1]	21,75[1]	MJ

1. **Sonesson et al. (2009)**
2. **Carlsson et al. (2009)**
3. **Ingvarsson (2002)**

Since the data in table 22 only include the production of pork until the farm-gate the data for the processes after the farm, such as transportation, slaughter and packaging, have been collected from an LCA by Ingvarsson (2002), table 23. Ingvarsson (2002) present the result in the categories: energy use, GWP, AP and EP, unfortunately are the units for AP and EP different from the one used in this report and can therefore not be included in the calculations.

Table 23: Data for transpiration, slaughter and the packaging production for pork (Ingvarsson, 2002).

	Transportation - slaughter	Slaughter	Packaging	unit
Global warming potential	1,90E-02	1,40E-01	1,50E-01	kg CO_2-eqv
Secondary energy	0,2	3,6	3,17	MJ

Appendix D- Transportation

In appendix D information about transportation distances, calculations for transportation and the emission data used for transportation are presented.

Transportation distances

In this appendix the distances used in the LCA calculations are presented.

Activity	Cities	Distance [km]
Apple		
Truck	Bolzano --> Malmö	1296
Train	Malmö --> Bro	652
From train station to warehouse. Transportation with heavy duty truck, short distance.	Bro --> Västerås	72
From warehouse to retailer. Transportation with heavy duty truck, long distance	Västerås - Göteborg	375
Bananas conventional		
Ship	Costa Rica --> Rotterdam	9377
Train	Hamburg --> Malmö	365
Train	Malmö - Bro	652
From train station to warehouse. Transportation with heavy duty truck (>16), short distance.	Bro --> Västerås	72
From warehouse to retailer. Transportation with heavy duty truck (>16), long distance	Västerås --> Göteborg	375
Bananas organic		
Ship	Dom. rep --> Rotterdam	7694
Train	Hamburg --> Malmö	365
Train	Malmö - Bro	652
From train station to warehouse. Transportation with heavy duty truck (>16), short distance.	Bro --> Västerås	72
From warehouse to retailer. Transportation with heavy duty truck (>16), long distance	Västerås --> Göteborg	375
Deep frozen cod		
From warehouse to retailer. Transportation with heavy duty truck (>16), long distance	Enköping - Göteborg	408
Egg		
From producer to Svenska lantägg. Transportation with heavy duty truck (<16), short distance.	Vara - Skara	35
From Svenska lantägg to Warehouse. Transportation with heavy duty truck (<16), long	Skara - Västerås	249

distance.		
From warehouse to retailer. Transportation with heavy duty truck (>16), long distance	Västerås - Göteborg	375
Milk		
From Arla to retailer. Transportation with heavy duty truck (>16), long distance.	Jönköping-Göteborg	145
Pork		
From producer to slaughter. Transportation with heavy duty truck (<16), long distance.		150
From warehouse to retailer. Transportation with heavy duty truck (>16), long distance	Västerås --> Göteborg	375

Calculations

Calculations on the fuel consumption have been made according to the two equations below. Equation 1 is used to calculate the fuel consumption associated with weight of the transported food product. Since the fuel consumption is expressed in [l/tkm] and the emission factors are expressed in [MJ] the physical properties for the fuel is included in the equation.

$$Energy = Density \cdot Heat\ value \cdot \frac{Fuel\ consumpion}{1000} \cdot Weight\ \cdot Distance$$

Density [kg/m^3]	– fuel density
Heat value [MJ/kg]	– heat value of the fuel
Fuel consumption [l/tkm]	– the vehicles fuel consumption
Weight [ton]	– weight of the load transported
Distance [km]	– transport distance
Energy [MJ]	– fuel energy

Equation 2 can be used to obtain the amount of fuel needed for refrigeration during the transportation, the equation is associated with the volume of the cargo transported.

$$Amount\ of\ fuel =\ Volume\ flow \cdot \frac{Fuel\ consumption\ per\ hour}{Refrigerated\ space} \cdot Duration$$

Volume flow [m^3]	– the volume of the product associated to the f.u.
Fuel consumption [l/h]	– the fuel consumption for refrigeration or use of refrigerant for the whole cargo
Refrigerates space [m^3]	– The volume of the refrigerated space
Duration [h]	– Time of transport
Amount of fuel [l]	– The amount of fuel needed for refrigeration or used amount of refrigerants associated to the f.u

Emission factors

Table 24 present the emission factors for RME in a heavy-duty truck, the data include both fuel chain and combustion in a truck. The data are composed out of the two data sets "*Rapeseed methyl ester (RME), cradle-to-gate, energy allocation*" (Hallberg et al., 2013c) and "*RME combustion in heavy duty truck or bus, Euro V, tank-to-wheel, f3 fuels*" (Hallberg et al., 2013d) found in the CPM LCA database.

Table 24: Emission factors for RME in a heavy-duty truck, Euro V. Cradle-to-wheel approach.

Direction	*FlowType*	*Substance*	*Quantity*	*Unit*	*Environment*
Input	Resource	Primary energy	1,27	MJ	Ground
Output	Emission	Carbon dioxide	2,23E-02	kg	Air
Output	Emission	Carbon monoxide	4,99E-04	kg	Air
Output	Emission	Methane	1,88E-05	kg	Air
Output	Emission	Nitrate	5,46E-04	kg	Water
Output	Emission	Nitrogen oxides	3,16E-04	kg	Air
Output	Emission	Nitrous oxide	2,71E-05	kg	Air
Output	Emission	Non-methane volatile organic compounds	6,39E-05	kg	Air
Output	Emission	Particles	9,47E-06	kg	Air
Output	Emission	Sulphur dioxide	2,76E-05	kg	Air

Table 25 present the emission factors for Diesel MK1 in a heavy-duty truck, the data include both fuel chain and combustion in a truck. The data are composed out of the two data sets "*Diesel MK1, cradle-to-gate, energy allocation - f3 fuels*" (Hallberg et al., 2013a) and "*RME combustion in heavy duty truck or bus, Euro V, tank-to-wheel, f3 fuels*" (Hallberg et al., 2013b) found in the CPM LCA database.

Table 25: Emission factors for diesel MK1 in a heavy-duty truck, Euro V. Cradle-to-wheel approach

Direction	*FlowType*	*Substance*	*Quantity*	*Unit*	*Environment*
Input	Resource	Crude oil	2,48E-02	kg	Ground
Input	Resource	Hard coal	4,49E-05	kg	Ground
Input	Resource	Lignite	2,79E-05	kg	Ground
Input	Resource	Natural gas	6,17E-04	kg	Ground
Input	Resource	Primary energy from biomass	1,23E-07	MJ	Ground
Input	Resource	Primary energy from hydro power	5,66E-03	MJ	Ground
Input	Resource	Primary energy from solar energy	3,22E-05	MJ	Ground
Input	Resource	Primary energy from solar energy	7,03E-05	MJ	Ground
Input	Resource	Uranium	1,48E-08	kg	Ground
Output	Emission	Ammonia	1,66E-11	kg	Water
Output	Emission	Ammonia	1,25E-08	kg	Air
Output	Emission	Ammonium	2,54E-08	kg	Water
Output	Emission	Carbon dioxide (fossil)	7,78E-02	kg	Air
Output	Emission	Carbon monoxide	4,93E-04	kg	Air
Output	Emission	Methane (fossil)	4,05E-05	kg	Air
Output	Emission	Nitrate	2,71E-08	kg	Water
Output	Emission	Nitrogen oxides	2,63E-04	kg	Air
Output	Emission	Nitrous oxide	6,17E-06	kg	Air
Output	Emission	Non-methane volatile organic compounds	8,40E-05	kg	Air
Output	Emission	Particles (unspecified)	4,51E-06	kg	Air
Output	Emission	Phosphate	3,17E-10	kg	Water
Output	Emission	Sulphur dioxide (SO_2)	1,42E-05	kg	Air

Table 26 present the emission factors for Diesel with 5% RME in a heavy-duty truck, the data include both fuel chain and combustion in a truck. The data are composed by combining 95% of the emissions from table 25 and 5% of the emissions of table 24.

Table 26: Emission factors for Diesel 5% RME in a heavy-duty truck, Euro V. Cradle-to-wheel approach

Direction	FlowType	Substance	Quantity	Unit	Environment
Input	Resource	Crude oil	2,36E-02	kg	Ground
Input	Resource	Hard coal	4,26E-05	kg	Ground
Input	Resource	Lignite	2,65E-05	kg	Ground
Input	Resource	Natural gas	5,86E-04	kg	Ground
Input	Resource	Primary energy	6,90E-02	MJ	Ground
Input	Resource	Uranium	1,41E-08	kg	Ground
Output	Emission	Ammonia	1,58E-11	kg	Water
Output	Emission	Ammonia	1,19E-08	kg	Air
Output	Emission	Ammonium	2,41E-08	kg	Water
Output	Emission	Carbon dioxide (fossil)	7,50E-02	kg	Air
Output	Emission	Carbon monoxide	4,94E-04	kg	Air
Output	Emission	Methane (fossil)	3,85E-05	kg	Air
Output	Emission	Methane (biogenic)	9,41E-07	kg	Air
Output	Emission	Nitrate	2,73E-05	kg	Water
Output	Emission	Nitrogen oxides	2,66E-04	kg	Air
Output	Emission	Nitrous oxide	7,21E-06	kg	Air
Output	Emission	Non-methane volatile organic compounds	8,30E-05	kg	Air
Output	Emission	Particles (unspecified)	4,76E-06	kg	Air
Output	Emission	Phosphate	3,01E-10	kg	Water
Output	Emission	Sulphur dioxide (SO_2)	1,49E-05	kg	Air

Table 27 present the emission factors for a transoceanic fright ship, the data include the production, operation and maintenance of the ship as well as the construction of the port. The data is collected from Ecoinvent, "*Transport, freight, sea, transoceanic ship, GLO*" (Spielmann et al., 2014).

Table 27: Environmental impact for a transoceanic ship, transport of 1 metric ton*km.

Impact category	Quantity	Unit
GWP	0,011588	kg CO_2-eqv
AP	0,00024224	kg SO_2-eqv
EP	0,00017967	kg NOx-eqv
Land use	0,00018468	m^2a

Table 28 present the emission factors for an electric freight train operating in Europe, the data represent the entire transport life cycle. The data is collected from Ecoinvent, "*Transport, freight train, electricity, Europe without Switzerland*" (Spielmann et al., 2007).

Table 28: Environmental impact for an electricity freight train, transport of 1 metric ton*km.

Impact category	Quantity	Unit
GWP	0,046819	kg CO_2-eqv
AP	0,00024648	kg SO_2-eqv
EP	0,000166	kg NOx-eqv
Land use	0,0053366	m^2a

Table 29 present the emission factors for an diesel freight train operating in Europe, the data represent the entire transport life cycle. The data is collected from Ecoinvent, "*Transport, freight train, diesel, Europe without Switzerland*" (Spielmann et al., 2007).

Table 29: Environmental impact for a diesel freight train, transport of 1 metric ton*km.

Impact category	Quantity	Unit
GWP	0,060039	kg CO_2-eqv
AP	0,00047541	kg SO_2-eqv
EP	0,00080114	kg NOx-eqv
Land use	0,0037064	m^2a

Appendix E – Inventory results

In this appendix the results from the life cycle inventory are presented.

	GWP [kgCO_2-eqv/kg]	AP [kgSO_2-eqv/kg]	EP [kgNO_3-eqv/kg]	Land use [m^2*year]	Energy use [MJ]
Apple, Conventional					
Production	1,11E-01	6,87E-04	5,06E-04	n/a	n/a
Transp. to warehouse	2,59E-01	7,53E-04	1,24E-03	3,64E-03	2,01E-01
Warehouse	-	-	-	-	-
Transp. to grocery store	5,81E-02	1,50E-04	2,87E-04	n/a	5,13E-02
Grocery store	8,33E-04	2,46E-06	2,27E-06	n/a	4,81E-01
Total	**4,29E-01**	**1,59E-03**	**2,03E-03**	**3,64E-03**	**7,33E-01**
Apple, Organic					
Production	6,84E-02	n/a	n/a	n/a	n/a
Transp. to warehouse	2,59E-01	7,53E-04	1,24E-03	3,64E-03	2,01E-01
Warehouse	-	-	-	-	-
Transp. to grocery store	5,81E-02	1,50E-04	2,87E-04	n/a	5,13E-02
Grocery store	8,33E-04	2,46E-06	2,27E-06	n/a	4,81E-01
Total	**3,86E-01**	**9,05E-04**	**1,53E-03**	**3,64E-03**	**7,33E-01**

	GWP [kgCO_2-eqv/kg]	AP [kgSO_2-eqv/kg]	EP [kgNO_3-eqv/kg]	Land use [m^2*year]	Energy use [MJ]
Banana, Conventional					
Production	3,64E-01	1,27E-03	1,50E-03	2,01E-01	n/a
Transp. to warehouse	8,24E-01	2,74E-03	2,25E-03	6,81E-03	1,75E-02
Warehouse	-	-	-	-	-
Transp. to grocery store	5,85E-02	1,52E-04	2,93E-04	n/a	5,22E-02
Grocery store	3,12E-04	9,20E-07	8,50E-07	n/a	1,80E-01
Total	**1,25E+00**	**4,17E-03**	**4,04E-03**	**2,07E-01**	**2,50E-01**
Banana, Organic					
Production	2,88E-01	n/a	n/a	n/a	n/a
Transp. to warehouse	8,10E-01	2,30E-03	1,92E-03	6,39E-03	1,72E-02
Warehouse	-	-	-	-	-
Transp. to grocery store	5,82E-02	1,50E-04	2,87E-04	n/a	5,13E-02
Grocery store	3,09E-04	9,12E-07	8,42E-07	n/a	1,78E-01
Total	**1,16E+00**	**2,45E-03**	**2,21E-03**	**6,39E-03**	**2,47E-01**

	GWP [$kgCO_2$-eqv/kg]	AP [$kgSO_2$-eqv/kg]	EP [$kgNO_3$-eqv/kg]	Land use [m^2*year]	Energy use [MJ]
Deep frozen cod, Organic					
Production	1,05E+00	n/a	n/a	n/a	n/a
Transp. to warehouse	4,19E-01	n/a	n/a	n/a	n/a
Warehouse	4,47E-03	2,08E-05	1,92E-05	n/a	n/a
Transp. to grocery store	6,97E-02	1,69E-04	3,24E-04	n/a	5,79E-02
Grocery store	4,86E-03	2,07E-05	1,91E-05	n/a	8,20E-04
Total	**1,55E+00**	**2,10E-04**	**3,63E-04**	**n/a**	**5,87E-02**

	GWP [$kgCO_2$-eqv/kg]	AP [$kgSO_2$-eqv/kg]	EP [$kgNO_3$-eqv/kg]	Land use [m^2*year]	Energy use [MJ]
Egg, Conventional					
Production	1,62E+00	2,45E-02	n/a	4,55E+00	n/a
Transp. to warehouse	5,84E-02	1,50E-04	2,88E-04	n/a	5,25E-02
Warehouse	-	-	-	-	-
Transp. to grocery store	6,52E-02	1,67E-04	3,21E-04	n/a	5,73E-02
Grocery store	3,15E-04	9,30E-07	8,59E-07	n/a	1,82E-01
Total	**1,75E+00**	**2,48E-02**	**6,10E-04**	**4,55E+00**	**2,92E-01**
Egg, Organic					
Production	1,32E+00	4,16E-02	n/a	7,10E+00	n/a
Transp. to warehouse	5,84E-02	1,50E-04	2,88E-04	n/a	5,25E-02
Warehouse	-	-	-	-	-
Transp. to grocery store	6,52E-02	1,67E-04	3,21E-04	n/a	5,73E-02
Grocery store	3,15E-04	9,30E-07	8,59E-07	n/a	1,82E-01
Total	**1,44E+00**	**4,19E-02**	**6,10E-04**	**7,10E+00**	**2,92E-01**

	GWP [$kgCO_2$-eqv/kg]	AP [$kgSO_2$-eqv/kg]	EP [$kgNO_3$-eqv/kg]	Land use [m^2*year]	Energy use [MJ]
Milk, Conventional					
Production	9,74E-01	1,01E-02	4,39E-02	1,74E+00	n/a
Transp. to warehouse	-	-	-	-	-
Warehouse	-	-	-	-	-
Transp. to grocery store	2,32E-02	5,97E-05	1,15E-04	n/a	2,05E-02
Grocery store	7,87E-05	2,84E-07	2,62E-07	n/a	5,55E-02
Total	**9,98E-01**	**1,02E-02**	**4,40E-02**	**1,74E+00**	**7,60E-02**
Milk, Organic					
Production	9,46E-01	1,17E-02	5,42E-02	2,95E+00	n/a
Transp. to warehouse	-	-	-	-	-
Warehouse	-	-	-	-	-
Transp. to grocery store	2,32E-02	5,97E-05	1,15E-04	n/a	2,05E-02
Grocery store	7,87E-05	2,84E-07	2,62E-07	n/a	5,55E-02
Total	**9,69E-01**	**1,18E-02**	**5,43E-02**	**2,95E+00**	**7,60E-02**

	GWP [$kgCO_2$-eqv/kg]	AP [$kgSO_2$-eqv/kg]	EP [$kgNO_3$-eqv/kg]	Land use [m^2*year]	Energy use [MJ]
Pork, Conventional					
Production	5,09E+00	n/a	n/a	1,31E+01	2,27E+01
Transp. to warehouse	2,89E-02	1,70E-03	1,25E-04	n/a	2,24E-02
Warehouse	1,22E-04	5,66E-07	5,23E-07	n/a	n/a
Transp. to grocery store	6,43E-02	1,56E-04	3,00E-04	n/a	5,36E-02
Grocery store	8,08E-04	2,51E-06	2,32E-06	n/a	4,91E-01
Total	**5,28E+00**	**1,23E-01**	**5,01E-01**	**3,23E+01**	**2,95E+01**
Pork, Organic					
Production	5,19E+00	1,21E-01	5,00E-01	3,23E+01	2,90E+01
Transp. to warehouse	2,89E-02	1,70E-03	1,25E-04	n/a	2,24E-02
Warehouse	1,22E-04	5,66E-07	5,23E-07	n/a	n/a
Transp. to grocery store	6,43E-02	1,56E-04	3,00E-04	n/a	5,36E-02
Grocery store	8,08E-04	2,51E-06	2,32E-06	n/a	4,91E-01
Total	**5,28E+00**	**1,23E-01**	**5,01E-01**	**3,23E+01**	**2,95E+01**