THE SWEDISH INSTITUTE FOR FOOD AND BIOTECHNOLOGY

SIK Report No 794

Greenhouse gas emissions from Swedish consumption of meat, milk and eggs 1990 and 2005

Christel Cederberg
Anna Flysjö
Ulf Sonesson
Veronica Sund
Jennifer Davis

September 2009

SIK Report
No 794 2009

Greenhouse gas emissions from Swedish consumption of meat, milk and eggs 1990 and 2005

Christel Cederberg
Anna Flysjö
Ulf Sonesson
Veronica Sund
Jennifer Davis

SR 794
ISBN 978-91-7290-285-5

SUMMARY

The goal of this study was to estimate the greenhouse gas (GHG) emissions related to consumption of animal products in Sweden 1990 and 2005, using a life cycle perspective. The objectives were:

- to estimate total and per capita GHG emissions in Sweden caused by the consumption of meat, dairy products and eggs from 1990 and 2005 and
- to investigate whether present trends in consumption of animal food in Sweden are sustainable from a global warming perspective.

Life cycle GHG emissions from the Swedish consumption of meat, dairy products and eggs 1990 and 2005 were analysed using LCA-methodology. The analysis dealt with the phases of animal production as shown in Figure 2.1. Also imports were considered. The calculated GHG emissions include primary production (at the farm-gate), transports to and processes at food industry and finally, transport to a retailer which we assume to be in Stockholm. The sum of GHG emissions from these subsystems is here called the product´s Carbon footprint, CF.

The Swedish consumption of meat has grown strongly during the period 1990-2005, while consumption of dairy products and eggs has been relatively stable. Parallel with this, domestic animal production has decreased (with the exception of poultry meat) and consequently meat imports have increased significantly.

Total GHG emissions from the consumption of dairy products decreased by ~14 % (close to 0.6 Mtons carbon dioxide equivalents, CO_2e) between 1990 and 2005, and amounted to approximately 3.5 Mtons CO_2e in 2005. The overall emission cut was an effect of efficiency gains in milk production while changes in consumption patterns were of minor significance. In 2005, the average consumption of fresh dairy products, cheese and milk powder was the source of emissions corresponding to approximately 380 kg CO_2e per capita. Egg consumption was relative stable over the time-period but import has increased due to a lowered domestic production. Total emissions from egg consumption were close to 0.18 Mtons CO_2e in 2005 corresponding to ~20 kg CO_2e per capita.

Total Swedish meat consumption increased by more than 50 %, from 460 to 706 million kg carcass weight, between 1990 and 2005. This strong consumption growth led to an increase of emissions of more than 2.3 Mtons CO_2e but since this growing consumption was based on imports, this has so far not been illustrated in the Swedish emission statistics. The growth of GHG emissions caused by the increased meat consumption from 1990 to 2005 corresponds to almost 30 % of all GHG emissions in Swedish agriculture in 2005 or close to 20 % of all GHG emissions from private cars in Sweden in 2005.

Beef was responsible for approximately 75 % of total GHG emissions from meat consumption in 2005, pork and poultry meat for 19 and 6 %, respectively. Average per capita emission due to the increasing meat consumption grew by over 50 % between 1990 and 2005. In 2005, consumption of pork, poultry and beef caused GHG emissions corresponding to close to 695 kg CO_2e per capita to be compared with 460 kg CO_2e in 1990.

Per capita GHG emissions caused by the consumption of all meat, milk and egg products increased by more than 16 % and reached ~ 1 100 kg CO_2e per capita in 2005. This corresponds to an average increase of approximately 1 % GHG emissions per year between 1990 and 2005. This growth occured despite the fact that the production of animal food in Sweden has became more efficient, delivering meat, milk and eggs with lower GHG emissions per produced unit in 2005 compared to 1990.

To stabilise the atmospheric GHG levels at 400 ppm CO_2e, a yearly global average emission of 2 ton CO_2e per capita in 2050 is suggested; hence, current per capita emission from animal food only, consumed in Sweden, is more than half of the required emission target from all consumption in 2050.

It is concluded that, despite reduced GHG emissions from the domestic production of meat, dairy and egg, predominantly consumed in Sweden, consumption-related emissions still have increased significantly due to an increased meat imports between 1990 and 2005. This leads us to the conclusion that mitigation in production will not be enough; also consumption patterns must be addressed to reach future emissions targets.

SAMMANFATTNING

I detta projekt har utsläppen av växthusgaser från konsumtionen av animaliska livsmedel i Sverige 1990 och 2005 analyserats, projektets två primära frågeställningar var:

- Hur stora var utsläppen totalt respektive per capita från animaliekonsumtionen i Sverige 1990 och 2005?
- Är trenderna för utsläppen från den svenska animaliekonsumtionen hållbara i ett klimatperspektiv?

Växthusgasutsläppen från den svenska konsumtionen av kött, mjölk och ägg analyserades med metodik från livscykelanalysen. Studien omfattade de delar av animalieproduktion som beskrivs i Figur 2.1. Även import ingick. Den studerade livscykeln omfattade primärproduktion (t o m gårdsgrind), transport till och processer i livsmedelsindustrin samt transporter till handeln vars geografiska plats antogs vara Stockholm. Summan av växthusgasutsläppen från dessa delsystem definierades som produktens ”Carbon footprint”, CF.

Den svenska köttkonsumtionen har ökat under perioden 1990-2005, medan konsumtion av mejeriprodukter och ägg har varit relativt stabil. Samtidigt minskade den svenska produktionen av animalier (undantaget kött från fjäderfä) och följaktligen har köttimporten ökat kraftigt.

De totala utsläppen från den svenska konsumtionen av mejeriprodukter minskade med ca 14 %, d v s 600 000 ton koldioxid-ekvivalenter, CO_2e mellan 1990 och 2005, och uppgick till 3,5 miljoner ton CO_2e 2005. Utsläppen reducerades framförallt p g a ökad effektivitet i mjölkproduktionen, medan förändrad konsumtion hade liten betydelse. Konsumtionen av mjölkprodukter innebär ett utsläpp motsvarande ca 380 kg CO_2e per capita år 2005. Äggkonsumtionen var stabil under perioden, men importen ökade p g a minskad svensk produktion. De totala utsläppen från äggkonsumtionen var ca 180 000 ton CO_2e 2005, d v s ca 20 kg CO_2e per capita.

Köttkonsumtionen i Sverige ökade med mer än 50 %, från 460 till 706 miljoner kg vara med ben mellan 1990 och 2005. Denna kraftiga konsumtionsökning medförde ökade växthusgasutsläpp om mer än 2,3 miljoner ton CO_2e men eftersom konsumtionstillväxten helt baseras på importerad vara har detta tidigare inte synliggjorts i svensk utsläppsstatistik. Ökningen av växthusgasutsläpp från den växande köttkonsumtionen mellan 1990 och 2005 motsvarar nästan 30 % av utsläppen från det svenska jordbruket 2005 eller nära 20 % av utsläppen från den svenska bilparken 2005.

Nötkött är ansvarigt för ca 75 % av utsläppen från köttkonsumtionen 2005, medan griskött och kyckling står för 19 respektive 6 %. Per-capita utsläppen från köttkonsumtionen växte med mer än 50 % under den undersökta tidsperioden. År 2005 orsakade den svenska köttkonsumtion växthusgasutsläpp om nära 695 kg CO_2e per capita att jämföra med 460 kg CO_2e per capita 1990.

Per-capita utsläpp från konsumtionen av alla animaliska livsmedel (nöt-, gris-, kycklingkött, mejeriprodukter samt ägg) ökade med mer än 16 % under 15-årsperioden och uppgick ca 1 100 kg CO_2e per capita år 2005. I medeltal innebär detta en årlig utsläppsökning om drygt 1 % och detta trots att den svenska animalieproduktionen blev mera effektiv under denna tidsperiod och levererade kött, mjölk och ägg med lägre ”Carbon footprint” 2005 jämfört med 1990.

För att stabilisera atmosfärskoncentrationen av växthusgaser vid 400 ppm CO_2e föreslås att de globala utsläppen inte skall överstiga 2 ton CO_2e per capita år 2050. Det innebär att nuvarande växthusgasutsläpp från Sveriges konsumtion av animaliska livsmedel, utgör mer än hälften än det globala utsläppsmålet för 2050 som alltså innefattar utsläpp från konsumtionen av alla varor och tjänster.

Resultaten från detta projekt visar tydligt att trots minskade växthusgasutsläpp från den svenska animalieproduktionen (som huvudsakligen konsumeras inhemskt) så har utsläppen från den svenska konsumtionen av animaliska livsmedel ökat kraftigt under de senaste 15 åren. Detta leder oss till slutsatsen att åtgärder för att minska utsläppen från den svenska jordbruksproduktionen inte kommer att vara tillräckligt för att reducera växthusgasutsläppen från livsmedelskonsumtionen i Sverige. Konsumentbeteende relaterat till prisnivåer och smakpreferenser samt trender vad gäller dieter, avfall etc måste också tas i beaktande för att nå målen för utsläppsminskningar.

TABLE OF CONTENTS

1 INTRODUCTION

The food system is an important contributor to greenhouse gas (GHG) emissions. Consumption of meat and dairy production is singled out to be responsible for a significant share of the food sector´s impact; according to the EU EIPRO project, meat and dairy products contribute to 14 % of global warming caused by all consumption in the EU-27 while only constituting to 6 % of the economic value (Weidema et al., 2009). In Sweden, food and environmental agencies have recently pointed out meat as a food item with significant environmental impact and now suggest modified food intake guidelines[1] including reduced meat consumption when health and environmental aspects are considered. This dual perspective is also increasingly debated at a global scale due to the rapid worldwide growth of meat consumption, e.g. by McMichael et al. (2007) who analyse the uneven global consumption of meat and the need for an international contraction and convergence strategy to combat health problems as well as environmental impacts caused by present meat-consumption patterns. The current global meat consumption is 100 g per capita and day, with about a ten-fold variation between high-consuming and low consuming populations. McMichael and colleagues (2007) suggest a meat consumption corresponding to 90 g per day and capita as a working global target, shared more evenly than today, and with no more than 50 g per day coming from red meat from ruminants.

So far, there are knowledge gaps on the total GHG emissions from the Swedish consumption of meat and dairy products and also on the effects of changing consumption patterns. The official statistics (National Inventory Reports, NIR) follow the reporting format according to the UNFCC[2] when estimating Sweden´s GHG emissions and this is done by a production-focused approach which does not take into account embedded emissions from import, nor those associated with aviation and shipping abroad (SEPA, 2009). Moreover, only emissions of methane and nitrous oxide are reported in the agriculture sector in NIR; emissions from fertiliser production are thus reported as industry processes and emission of fossil CO_2 as energy use. A complete picture of the whole food sector´s emission is therefore not possible to obtain from the current method for reporting GHG emissions where the nation´s production is the base.

The overall goal of this study was to estimate the GHG emissions related to consumption of animal products in Sweden 1990 and 2005, using a life cycle perspective. The objectives were:

- to estimate total and per capita GHG emissions caused by consumption of meat, dairy products and eggs in 1990 and 2005 and
- to investigate whether present trends in consumption of animal products in Sweden are sustainable from a global warming perspective.

The report is structured as follows: in section 2, methods and studied systems are described; methods are also more thoroughly presented in SIK-report 793 including the analysis of production changes (Cederberg et al., 2009a). Section 3 and Appendix 1 give a background description of the consumption of meat, dairy and egg in 1990 and 2005. In Section 4 and Appendix 2, we report estimates of GHG emissions per product unit (so-called Carbon Footprints) of meat, dairy and egg products consumed in Sweden 1990 and 2005. The results, reported as total GHG emission and per capita emission from Swedish consumption of animal products, are presented in section 5 and Appendix 3, and further discussed in section 6.

This research project was financed by the Swedish Farmers´ Foundation for Agricultural Research (Stiftelsen Lantbruksforskning).

[1] http://www.euractiv.com/en/cap/sweden-promotes-climate-friendly-food-choices/article-183349
[2] United Nations Framework Convention on Climate Change

2 METHODS

In this report, GHG emissions from the Swedish consumption of meat, dairy products and eggs in 1990 and 2005 are estimated using a life cycle perspective. The analysis deals with the phases of animal production as shown in Figure 2.1

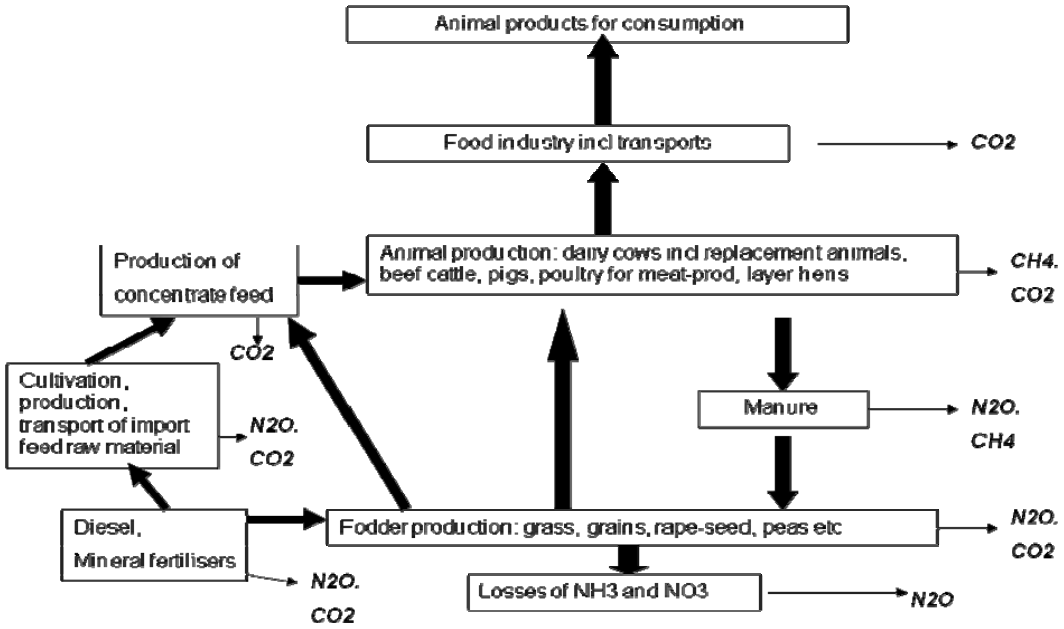

Figure 2.1 This figure shows a flow diagram of the production systems studied and GHG emissions considered in the analysis

GHG emissions from primary production (system-boundary farm-gate) in Sweden are described by Cederberg et al (2009a). Data on emissions from transport and food industry are presented in section 4 and Appendix 2. For imported products, data on GHG emissions were collected from as recent publications as possible. Here, we analyse the life-cycle GHG emissions until the meat/dairy/egg product is delivered at a retailer in Stockholm. The sum of GHG emissions per kg product delivered at the retailer is defined as the product´s Carbon Footpint, CF. The investigated products are summarised in Table 2.1.

Table 2.1 Overview of studied animal products and product unit when estimating the product carbon footprint, CF

	Product	Studied unit for estimating CF
Meat	Pork Chicken meat Beef	1 kg carcass weight (CW)
Dairy products	Fresh dairy products Cheese Milk powder	1 kg fresh milk product 1 kg cheese 1 kg milk powder
Eggs	Eggs	1 kg eggs

Delimitations
In this study of consumption-related GHG emissions, some important parts of the food supply chain are excluded. Emissions from retailers and shops, consumers (shopping transport and food storing/preparation), packaging and food waste handling are not included in the study. This is because the focus of the study was to compare and analyse trends of GHG emissions from production and consumption of animal products between 1990 and 2005, and earlier studies show that for animal products, the later parts of the supply chain are of minor importance to the overall emission picture. Also, there is a considerable lack of data on emissions from private shopping transports, retailer and shops etc in the early 1990s, and this would make it difficult to analyse trends including this part of food´s life-cycle.

In the estimates of GHG emissions from primary production in Sweden (Cederberg et al., 2009a), total resource use and emissions have been balanced against national agricultural statistics and this top-down model approach should include most emissions related to animal production in Sweden. Not included in the analysis of primary production are emissions from capital goods (production of farm buildings and farm machinery), production of medicines and pesticides. Since the main purpose of this study was to compare the emissions in 2005 with 1990, this omission should be of minor significance.

CO_2-emissions from land use change (LUC) are not included and this can lower as well as increase the investigated products´ Carbon Footprint. In Sweden, the arable land (mineral soils) is considered to be in balance, not being a carbon source while permanent grassland for grazing are known as carbon sinks, while peat soils are net carbon sources (SEPA 2009). The area of permanent grassland has increased over the studied time period and consequently, also the carbon sink. If this LUC was included, the GHG estimates would probably be lower in 2005 compared to 1990 due to the increase of this carbon sink. On the other hand, LUC emissions caused by imported feed and beef are not included, and since there has been an increased import of protein feed as well as beef from regions with on-going deforestation between 1990 and 2005, these consumption-related emissions are underestimated in 2005 compared to 1990. The reason for omitting GHG from LUC is that there is still no consensus methodology on how to apply it in life cycle accounting of GHG emissions from land-based products. Also, inadequate data are a problem when estimating LUC.

Handling import/export – net import
Imports of meat, milk products and eggs were accounted as “net import”. When the consumption of a product was bigger than the Swedish production, the size of the import was then calculated as the difference between total domestic consumption and total domestic production of the product. This difference we define as the “net import”. To calculate emissions from the import, the net import was multiplied with a Carbon Footprint based on international publications. The Swedish export of animal products is small.

Global Warming Potential, GWP
The GHG emissions were weighted according to the latest IPCC report in a 100 year perspective with 1 kg of carbon dioxide (CO_2) as 1 kg CO_2, 1 kg methane (CH_4) as 25 kg CO_2 and 1 kg nitrous oxide (N_2O) as 298 kg CO_2 (Barker et al., 2007). The sum of emitted GHGs (fossil CO_2, CH_4, N_2O) per product were defined as the Carbon Footprint and expressed as CO_2-equivalents (CO_2e).

3 CONSUMPTION OF MEAT, MILK AND EGGS

The consumption of meat in Sweden has increased during the period 1990-2005, while consumption of dairy products (with the exception of butter) and eggs has been relatively stable. Parallel with this, production of animal products has decreased, with the exception of poultry meat, and consequently meat imports have increased significantly. In Appendix 1, data for production, consumption, import and export of animal food production for the year 1990 and 2005 are described more thoroughly (Board of Agriculture 2000, 2003, 2007).

When estimating the GHG emissions from meat consumption, meat from lamb, horse, game and reindeer were not included due to lack of data of emissions from these products. However, consumption of these meat products is very low[3]; pork, beef and poultry meat analysed here make up almost 95 % of total consumption.

3.1 Pork

The Swedish consumption of pig meat increased by ~20 % between 1990 and 2005 and production was slightly reduced. Imports show an on-going increasing trend during the period, see Figure 3.1,

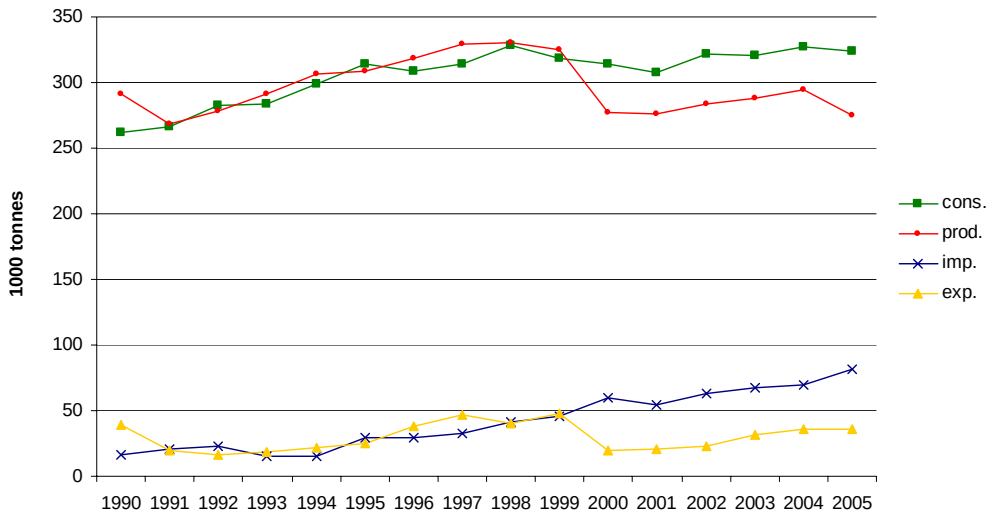

Figure 3.1 Total Swedish consumption, production, import and export of pork, carcass weight (1 000 tonnes) 1990 and 2005.

Per capita consumption increased from 30.6 to 36 kg pork (meat with bone) from 1990 to 2005; Denmark and Germany are the dominating importing countries for pork, see Table 3.1

Table 3.1 Origin of the Swedish pork import, 2005

	1 000 tonnes	Share
Denmark	46.6	0.58
Germany	22.3	0.28
Finland	3.3	0.04
Others		0.10
Total import	81.0	1

[3] The consumption of lamb is very low in Sweden, only 1.2 kg per capita in 2005 (see Appendix 1)

3.2 Poultry meat

The Swedish consumption of poultry meat increased noticeably between 1990 and 2005, although from a low level, as did production. However, domestic production grew mainly in the beginning of the period while the import has increased significantly in the early 2000s, Figure 3.2.

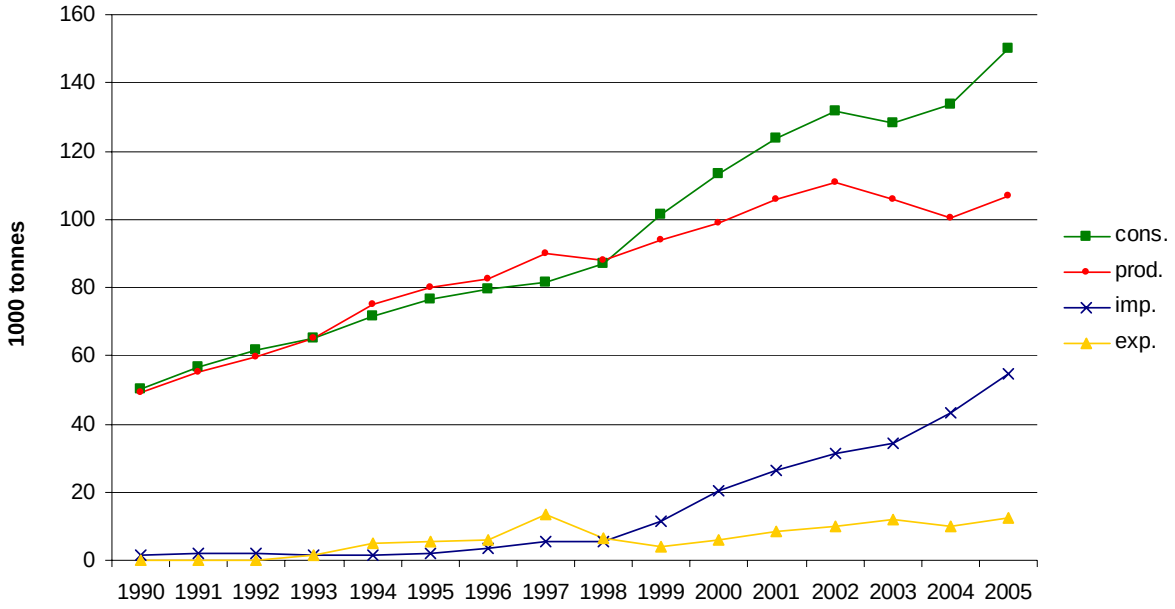

Figure 3.2 Total Swedish consumption, production, import and export of poultry meat, carcass weight (1 000 tons) 1990 and 2005.

Per capita consumption of poultry meat increased from ~6 to more than 16 kg in 2005. The import of poultry meat is mainly sourced from Denmark. Data for imports are based on Danish statistics of poultry meat exported to Sweden which should be more correct than the Swedish official statistics (Donis, M., pers comm. 2008).

3.3 Beef

Beef consumption increased by more than 50 % between 1990 and 2005, while production was relatively stable. This strong consumption growth was provided for by a strong increase of beef imports, see Figure 3.3.

Per capita[4] beef consumption increased from 17.3 kg to 25.5 kg[5] between 1990 and 2005; in 2005 close to 50 % of total beef consumption was imported.

In Table 3.2, the origin of the Swedish beef import is shown. However, the statistics do not disclose where the beef is produced, since beef imported to one EU nation from outside EU (third country) and sold further on to Sweden is registered as imported from EU (and not from a third country).

[4] Swedish population was 8.57 and 9.05 millions in 1990 and 2005, respectively.
[5] Total consumption, meat with bone.

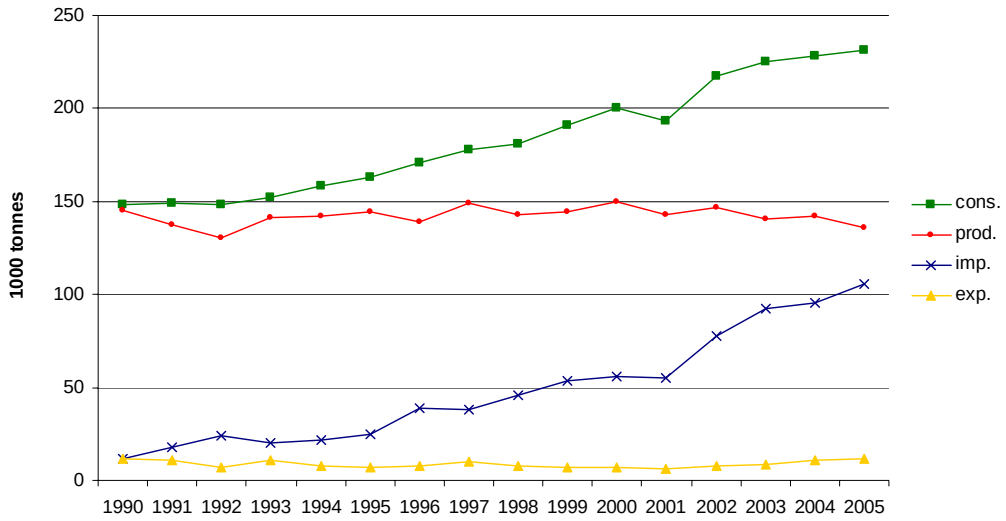

Figure 3.3 Total Swedish consumption, production, import and export of beef (including veal), carcass weight (1 000 tons) 1990 and 2005.

Table 3.2 Origin of the Swedish beef import, 2005

	1 000 tonnes	Share
Ireland	35.1	0.33
Germany	22.2	0.21
Denmark	16.7	0.16
Brazil	10.3	0.10
The Netherlands	6.1	0.06
Others		0.15
Total import	105.8	1

3.4 Dairy products

Consumption of milk products[6] has been stable between 1990 and 2005. The import and export are very low with the exception of cheese. The consumption of cheese increased by 20 % between 1990 and 2005, and one third of this was imported in 2005.

Production of butter and milk powder is greater than consumption and these products are the only animal products that are produced in larger volumes than domestic consumption, thus having a net export (see Appendix 1).

[6] Milk and soured products

3.5 Eggs

Statistics on consumption, production, import and export of eggs (including other egg products) in Sweden is shown in Figure 3.4.

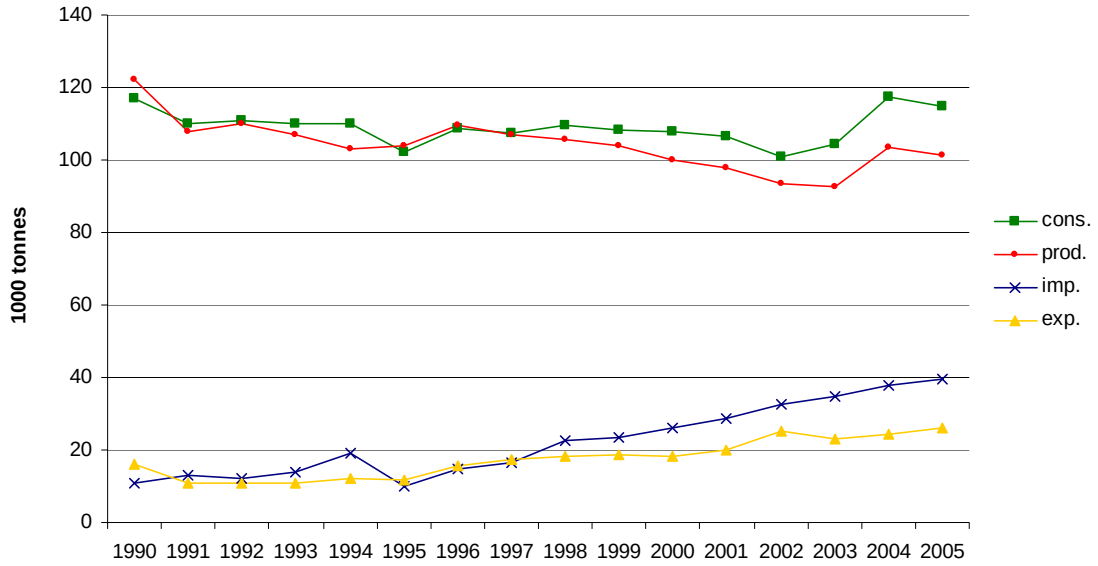

Figure 3.4 Total Swedish consumption, production, import and export of eggs (1 000 tons) between 1990 and 2005.

Per capita consumption was relatively stable, 13.7 kg and 12.7 kg in 1990 and 2005, respectively. In 2005, Finland was the dominating source for import of whole eggs while other egg products were sourced also from the Netherlands and Denmark.

4 CARBON FOOTPRINTS OF MEAT, MILK AND EGGS

The calculated GHG emissions include primary production (at the farm-gate), transports to and processes at food industry and finally, transport to retail which was assumed to be in Stockholm. The sum of emissions from these subsystems is called the product´s Carbon Footprint, CF. GHG emissions from primary production of meat, milk and eggs in the Swedish agriculture were deeply analysed and reported in SIK-report no 793, (Cederberg et al., 2009a).

In this section and in Appendix 2, the CF used in the calculations and the sources of data are described.

Pork
In Table 4.1, Carbon footprints, CF, for pork meat are shown. Data from Danish pig production were used for all imported pork (Dalgaard et al., 2008); however, this CF is based on a consequential LCA[7] of Danish pork production and thus not fully comparable with the CF for Swedish pork. As seen in Table 4.1, the CF for Swedish pork has been reduced by around 15 % since 1990 due to more efficient production and lower nitrogen emissions from manure management, see further Cederberg et al. (2009a).

Table 4.1 Carbon footprints for pork meat (kg CO_2e per kg CW) used in the calculations

	1990, Sweden	2005, Sweden	2005, Import
Primary production, at farm-gate	4.0	3.4	3.6
Meat product, CF at retailer	4.14	3.54	3.82

Poultry meat
As most poultry meat is imported from Denmark, data on Danish chicken meat production was taken from the Danish Food LCA database (www.lcafood.dk), see further Appendix 2 and Table 4.2. The Danish CF of chicken meat was published a few years ago and the latest GWP-factors[8] were not used in these calculations and can therefore be slightly overestimated. The CF for Swedish chicken meat has been reduced by around 20 % since the early 1990s, which is an effect of a change of fuel for heating the stables (oil has to a large extent been replaced by biofuels) and also more effective production.

Table 4.2 Carbon footprints for chicken meat (kg CO_2e per kg CW) used in the calculations

	1990, Sweden	2005, Sweden	2005, Import
Primary production, at farm-gate	2.51	1.93	2.57
Meat product, CF at retailer	2.74	2.15	2.88

Beef
Nguyn et al. (2009) report GHG emissions from primary production of beef in Europe in the range of 15-27 kg CO_2e kg per kg CW at farm-gate, with beef produced as by-products from milk production in the lower end of the range and beef produced in "cow-calf systems" in the upper end. Here, we assumed a CF of 20.5 kg CO_2e per kg CW for imported beef from Europe and this could be a little too low if the majority of beef imports are meat from "cow-calf systems" system and not as by-products from dairy production (see further section 6.2).

[7] In consequential LCA, marginal data and system expansion is used. To calculate the GHG emissions from Swedish production 1990 and 2005, attributional LCA was used, i.e. average data and allocation for co-product handling (see further Cederberg et al., 2009a)
[8] 1 kg CH_4 was weighted as 21 kg CO_2e and 1 kg N_2O weighted as 310 kg CO_2e. Since N_2O is considerable part of chicken meats CF this can lead to an over-estimation compared to the CFs for Swedish production where 1 kg N_2O is weighted as 298 kg CO_2e.

The analysis of GHG emission from different European beef production system was a part of the EU-project IMPRO-meat and dairy (Weidema et al., 2009).

Carbon footprint of average Brazilian beef production has been investigated within this project and is fully presented in SIK-report no 792 (Cederberg et al., 2009b).

The higher CF for Swedish beef in 2005 compared to 1990 is explained by that in 1990 around 85 % of the beef production had its origin in the dairy sector as meat from slaughtered dairy cows and surplus calves that were further raised for beef production. In 2005, around 65 % of production came as by-products from the milk sector, thus a larger share of the beef production came from "cow-calf systems" in 2005 leading to a higher Carbon footprint (see further section 6.2).

Table 4.3 Carbon footprints for beef (kg CO_2e per kg CW) used in the calculations

	1990, Sweden	2005, Sweden	2005, imp EU	2005, imp Brazil
Primary production, at farm-gate	18	19.8	20	28.2
Meat product, CF at retailer	18.2	20	20.5	28.7

Dairy products
Primary production of milk has become significantly more efficient during the studied time-period mostly due to a milk yield increase of close to 2 000 kg per dairy cow and year. When dividing the emissions between milk and beef, we used an allocation factor of 85 % to milk and 15 % to meat (culled cows and surplus calves further to be raised in beef production), this resulted in a CF at farm-gate corresponding to 1.27 kg CO_2e per kg ECM[9] in 1990 and 1.02 kg CO_2e in 2005 (Cederberg et al., 2009a). From this we estimated CF at retailer for fresh dairy products (milk, yogurt, cream), cheese and milk powder, see Table 4.4.

Table 4.4 Carbon footprints for Swedish dairy products (kg CO_2e per kg product) used in calculations

	1990, fresh products	2005, fresh products	1990, cheese	2005, cheese	1990, milk powder	2005, milk powder
CF at retailer	1.31	1.08	13.3	10.8	14	11.3

Farm-gate emissions were calculated per kg energy corrected milk and this was then adjusted to the true fat-content of the milk delivered to dairies. We did not include butter in the calculations since butter fat is a by-product mostly from cheese production, so the emissions from butter are included in the other dairy products. We assumed the same fat content on average in the dairy products for 1990 and 2005.

In 2005, there are some imports of cheese otherwise the consumption of milk products is to a high degree based on domestic production. For the cheese import, we used the Swedish data for 2005 but added 10 % to compensate for higher emissions from milk production, processing and transport[10].

The drying of milk to powder is an energy consuming process and between 1990 and 2005, the energy source in industry has changed and significantly more biofuels was used in 2005. This, together with the more efficient farm milk production, explains the quite large reduction of milk powder CF in 2005 (Table 4.4).

[9] ECM=energy corrected milk
[10] This assumption was based upon comparisons of GHG emission per kg milk in several industrialised countries showing Swedish milk production in the lower range (Sevenster & de Jong, 2008).

Eggs

In Table 4.5, carbon footprints used for eggs are shown, we found small changes in CF during the 15 year period, probably due to changes in protein feed composition (Cederberg et al., 2009a). Import in 2005 came from Finland, no data were found for Finnish egg production, instead we used data from the Danish food-database (www.lcafood.dk).

Table 4.5 Carbon footprints for eggs (kg CO_2e per kg) used in the calculations

	1990, Sweden	2005, Sweden	2005, Import
Primary production, at farm-gate	1.42	1.42	2
Egg product, CF at retailer	1.47	1.47	2.15

5 RESULTS

5.1 Meat

5.1.1 Pork

The Swedish consumption of pork meat was 324 000 tons in 2005 corresponding to 35.8 kg cap^{-1} and this was an increase of approximately 20 % over 15 years, see Table 5.1. The Swedish per capita consumption was a little lower than average consumption of EU-25 (42.5 kg cap^{-1}) but higher than the US (29 kg cap^{-1}).

Table 5.1 Swedish consumption of pork, total tons (meat with bone, CW) and kg per capita in 1990 and 2005

	1990 - consumption		2005 - consumption	
	Total, tons	**Per cap, kg**	**Total, tons**	**Per cap, kg**
Domestic production	262 000	30.5	275 100	30.4
Net import	0	0	48 900	5.4
Total consumption	262 000	30.5	324 000	35.8

Life-cycle GHG emissions from the Swedish consumption of pork increased by approximately 10 % between 1990 and 2005 and totalled 1.16 million tons CO_2e in 2005, see Figure 5.1. In 2005, emissions from the net import represented almost 20 % of total emissions. Due to efficiencies in feed production and feeding, Swedish pig production is carried out with lower emissions in 2005 compared to 1990 (Cederberg et al., 2009a), but the improvements were not enough to compensate for the overall consumption growth leading to increasing consumption-related emissions. In 2005, the capita consumption of 35.8 kg pork was responsible to GHG-emissions of ~128 kg CO_2e per capita, see also Appendix 3.

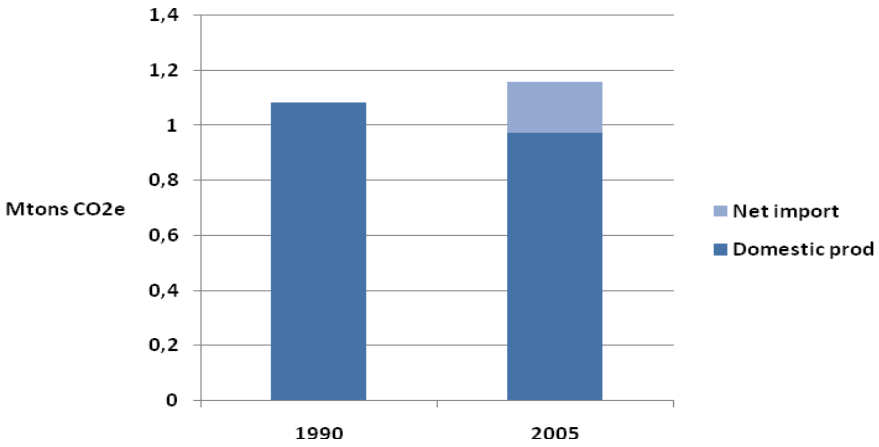

Figure 5.1 Total emissions (million tons CO_2e) from the Swedish consumption of pork in 1990 and 2005

5.1.2 Poultry meat

In 2005, the Swedish consumption of poultry meat was 150 300 ton or 16.6 kg per capita. This is lower than average for EU-25 (22.6 kg cap^{-1}) and considerably lower than the US consumption (53.4 kg cap^{-1}).

Table 5.2 Swedish consumption of poultry meat, total tons (meat with bone, CW) and kg per capita in 1990 and 2005

	1990 - consumption		2005 - consumption	
	Total, tons	**Per cap, kg**	**Total, tons**	**Per cap, kg**
Domestic production	49 100	5.7	106 900	11.8
Net import	1 300	0.2	43 400	4.8
Total consumption	50 400	5.9	150 300	16.6

Total GHG emissions from poultry meat consumption increased by more than 150 % between 1990 and 2005, reaching 355 000 tons CO_2e in 2005 of which 35 % came from net import of chicken meat[11]. The Swedish per capita consumption of 16.6 kg poultry meat in 2005 caused a GHG emission of approximately 39 kg CO_2e per capita.

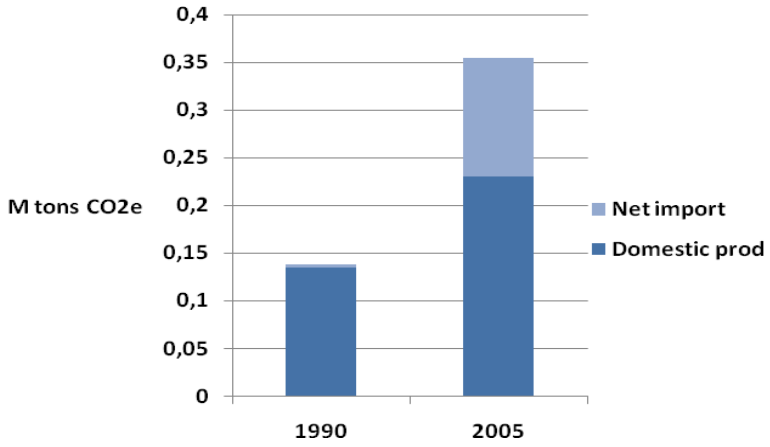

Figure 5.2 Total GHG emissions (million tons CO_2e) from the Swedish consumption of poultry meat in 1990 and 2005

5.1.3 Beef

The consumption of beef was 231 000 tons in 2005 corresponding to 25.6 kg cap^{-1} and this was an increase of more than 50 % over 15 years, see Table 5.3. The Swedish per-capita consumption of beef was considerably larger than average EU-25 (17.8 kg CW cap^{-1}) but significantly lower than the US consumption (43 kg CW cap^{-1}).

Table 5.3 Swedish consumption of beef, total tons (meat with bone, CW) and kg per capita in 1990 and 2005

	1990 - consumption		2005 - consumption	
	Total, tons	**Per cap, kg**	**Total, tons**	**Per cap, kg**
Domestic production	143 800	16.7	135 900	15
Net import	4 300	0.5	95 300	10.5
Total consumption	148 100	17.2	231 200	25.6

The GHG emissions caused by the total Swedish beef consumption in 2005 totalled approximately 4.75 Mtons CO_2e, an increase by more than 75 % since 1990, see Figure 5.3. The total growth of emissions between 1990 and 2005, corresponding to 2 Mtons CO_2e, is an effect of the massive increase of beef imports. Per capita consumption in 2005 corresponding to 25.6 kg meat per capita and this caused an emission of approximately 525 kg CO_2e per capita, see also Appendix 3.

[11] A small share of the total poultry meat consumption is turkey and goose and there are no data on CF on these poultry meats. We used the CF for chicken meat (broiler) for all poultry meat consumption regardless of it was meat from slaughter chicken, turkey or goose.

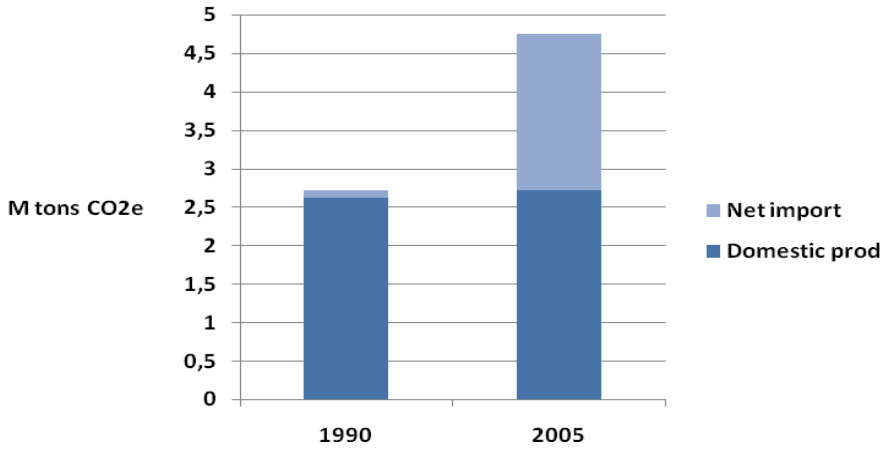

Figure 5.3 Total GHG emissions (million tons CO_2e) from the Swedish consumption of beef in 1990 and 2005

5.1.4 Total meat consumption

Total Swedish meat consumption (pork, poultry and beef) increased by more than 50 %, from 460 to 706 million kg carcass weight, between 1990 and 2005. This strong consumption growth led to an increase of emissions of more than 2.3 Mtons CO_2e, see Figure 5.4. Beef consumption is responsible for approximately 75 % of total emissions in 2005, pork and poultry meat for 19 and 6 %, respectively.

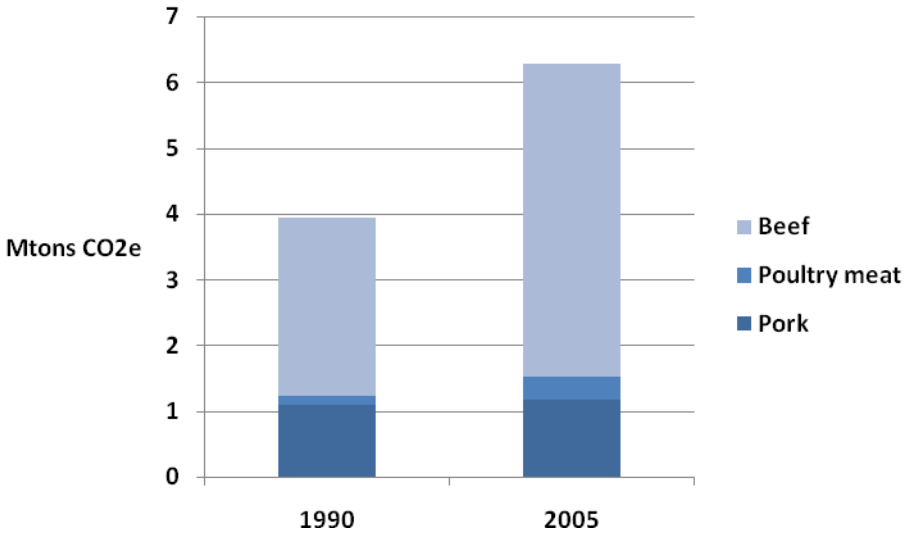

Figure 5.4 Total GHG emissions (million tons CO_2e) from the Swedish consumption of beef, pork and poultry meat in 1990 and 2005

GHG emissions per capita caused by the average meat consumption in Sweden increased by more than 50 % between 1990 and 2005 see Figure 5.5. In 2005, average consumption of pork, poultry and beef caused GHG emissions corresponding to close to ~695 kg CO_2e per capita to be compared with ~460 kg CO_2e in 1990.

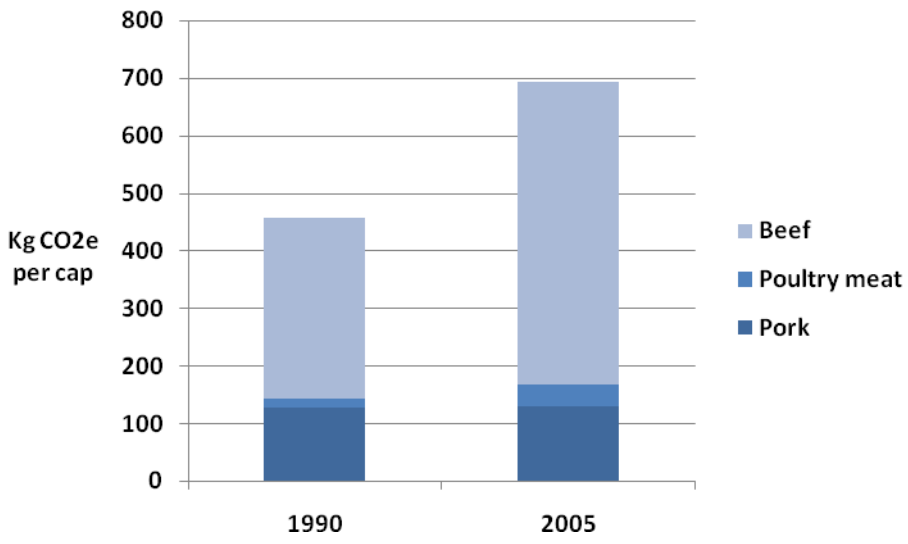

Figure 5.4 Average emissions, kg CO_2e per capita, from meat consumption in Sweden 1990 and 2005

5.2 Dairy products

5.2.1 Fresh products

The total consumption of fresh dairy products (milk, soured products and cream) decreased by approximately 4 % between 1990 and 2005. Of a total consumption of 1.36 Mtons products in 2005, less than 1 % of were imported. Average per capita consumption was ~150 kg milk products in 2005 (Table 5.4).

Table 5.4 Swedish consumption of fresh dairy products, total tons and kg products per capita in 1990 and 2005

	1990		2005	
	Total, tons	**Per cap, kg**	**Total, tons**	**Per cap, kg**
Domestic production	1 422 300	165.6	1 346 200	148.8
Net import			13 000	1.4
Total consumption	1 422 300	165.6	1 359 200	150.2

The GHG emissions from the consumption of fresh dairy products were reduced by more than 20 % (approximately 400 000 tons CO_2e) during the 15-yr period. In 2005, total emissions were close to 1.5 Mtons CO_2e, see Figure 5.5. Only a smaller share of the emission cut between 1990 and 2005 is due to reduced consumption, the main explanation is the efficiencies in milk production that resulted in lower GHG emissions per kg milk produced and consequently reduced emissions from milk consumption.

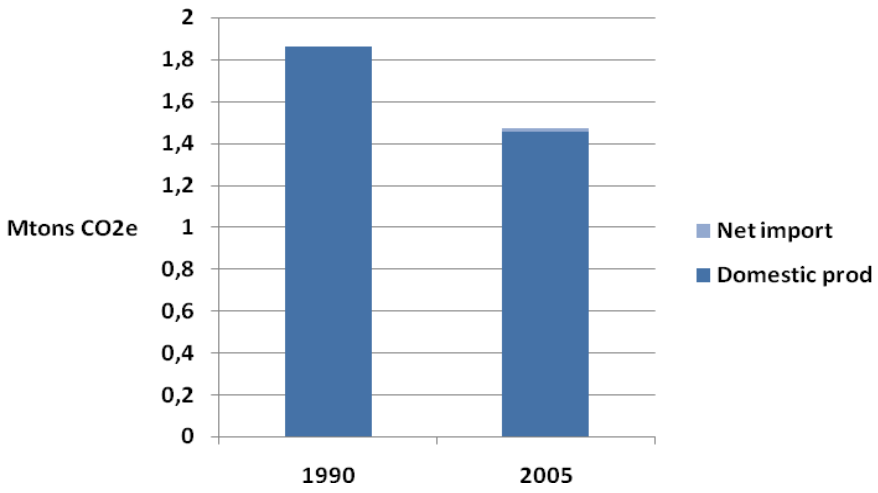

Figure 5.5 Total GHG emissions (million tons CO_2e) from the Swedish consumption of fresh dairy products in 1990 and 2005

5.2.2 Cheese

Total cheese consumption was 160 000 tons in 2005 and this was an increase by 20 % since 1990. Per capita consumption of cheese corresponded to 17.7 kg in 2005, Table 5.5.

Table 5.5 Swedish consumption of cheese, total tons and kg per capita in 1990 and 2005

	1990		2005	
	Total, tons	**Per cap, kg**	**Total, tons**	**Per cap, kg**
Domestic production	115 700	13.5	118 200	13.1
Net import	17 800	2	42 200	4.7
Total consumption	133 500	15.2	160 400	17.7

GHG emissions from cheese consumption did not increase during the time period, despite increasing consumption (Figure 5.6). This is an effect of the efficiency gains in Swedish milk production leading to lower GHG emissions per ton milk. In 2005, approximately 1.7 Mtons CO_2e were emitted due to Swedish cheese consumption corresponding to an average per capita emission of roughly 190 kg CO_2e per capita.

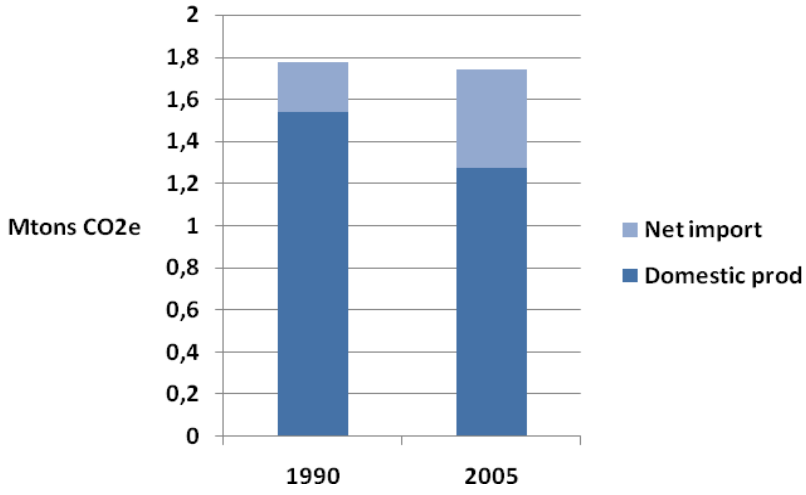

Figure 5.6 Total GHG emissions (million tons CO_2e) from the Swedish consumption of cheese in 1990 and 2005

5.2.3 Milk powder

Overall consumption of milk powder fell with more than 20 % between 1990 and 2005, corresponding to 2.4 kg product per capita in 2005 (Table 5.6).

Table 5.6 Swedish consumption of milk powder, total tons and kg per capita in 1990 and 2005

	1990		2005	
	Total, tons	**Per cap, kg**	**Total, tons**	**Per cap, kg**
Domestic production	57 600	6.7	48 500	5.4
Net import	0	0	0	
Total consumption	28 700	3.4	22 100	2.4

Emissions from the consumption of milk powder were reduced by close to 40 % between 1990 and 2005. This was a combined effect of reduced consumption and significantly lowered GHG emission per kg milk powder.

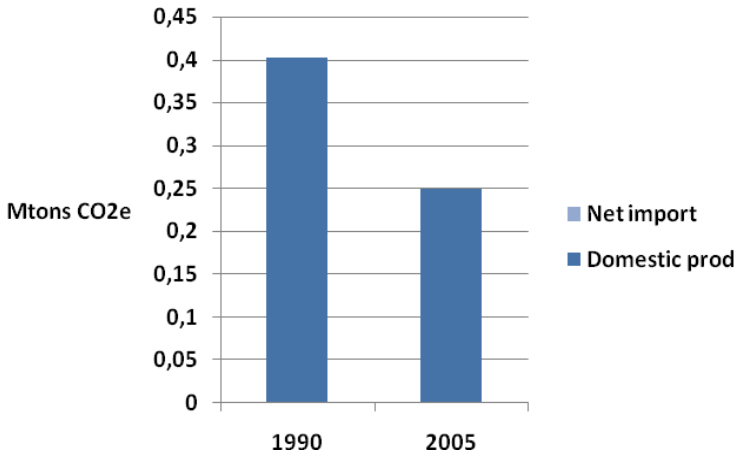

Figure 5.7 Total GHG emissions (million tons CO_2e) from the Swedish consumption of milk powder in 1990 and 2005

5.2.4 Total dairy products

Total emissions from consumption of all dairy products decreased by ~14 % (close to 0.6 Mtons CO_2e) and totalled approximately 3.5 Mtons CO_2e in 2005, see Figure 5.8. Overall emission cuts are due to efficiency gains in milk production while changes in consumption patterns are of minor significance. In 2005, the average consumption of fresh dairy products, cheese and milk powder was the source of emissions corresponding to approximately 380 kg CO_2e per capita, see also Appendix 3.

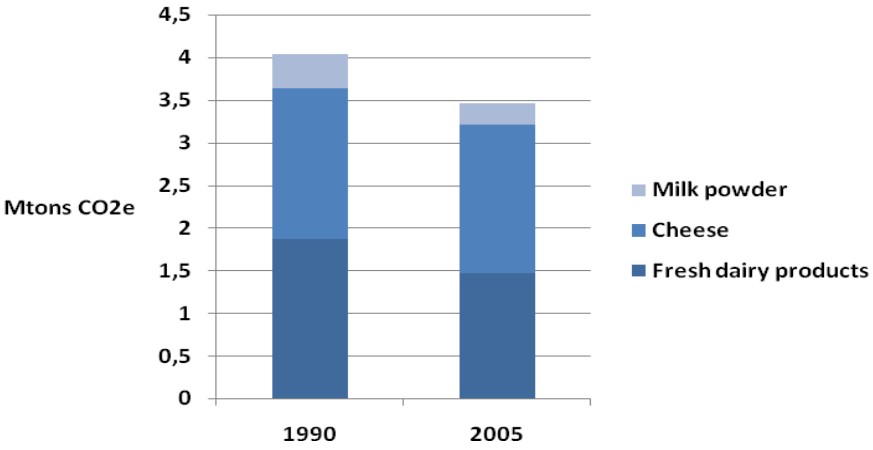

Figure 5.8 Total GHG emissions (million tons CO_2e) from the Swedish consumption of dairy products in 1990 and 2005

5.3 Eggs

Egg consumption was relatively stable over the time-period but import has increased due to a lowered domestic production. Total emissions from egg consumption were close 0.18 Mtons CO_2e in 2005 (Figure 5.8), corresponding to ~20 kg CO_2e per capita.

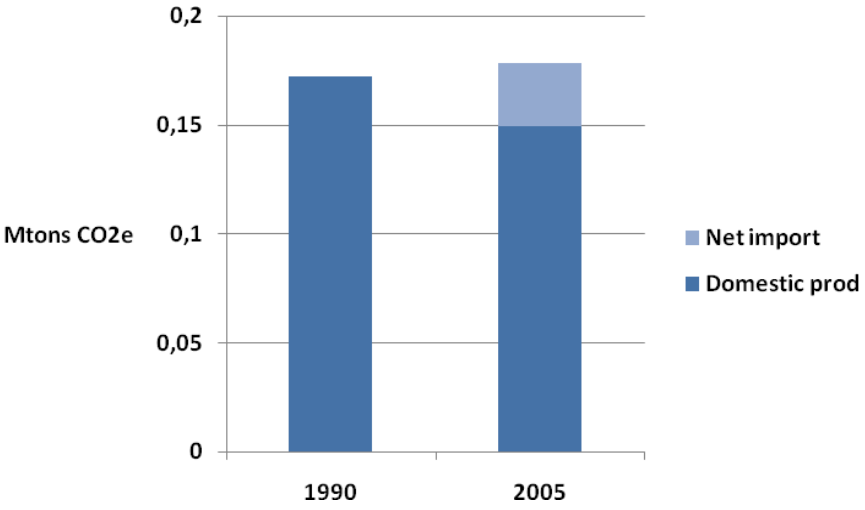

Figure 5.8 Total GHG emissions (million tons CO_2e) from the Swedish consumption of eggs in 1990 and 2005

6 DISCUSSION

Emission trends
Total GHG emissions from Swedish consumption of meat, dairy products and eggs increased from 8.1 Mtons CO_2e in 1990 to approximately 10 Mtons CO_2e in 2005, i.e. an increase by approximately 1.8 Mtons CO_2e (22 %), see Table 6.1 and Appendix 3. The soaring meat consumption, especially of beef, during the 15-year period is the main cause for the growing emissions. The increase in beef consumption alone is responsible for more than 85 % of the total emission increase during the studied period.

Table 6.1 Total GHG emissions (Mtons CO_2e) from consumption of meat, dairy products and eggs in Sweden 1990 and 2005

	1990, Mtons CO_2e	2005, Mtons CO_2e	Change, Mtons CO_2e	Change, relative
Meat	3.93	6.27	+2.34	+59 %
Dairy	4.04	3.46	-0.6	- 14 %
Eggs	0.17	0.18	+0.01	+4 %
Animal food products, total	**8.14**	**9.91**	**+1.75**	**+22 %**

Emissions from the food sector cannot be singled out separately from National Inventory Reports (NIR) of GHG emissions and direct comparisons with the official statistics are therefore not possible to carry out. The closest comparison with the result presented here would be the emission trends for Swedish agriculture production, which were reported to be reduced by 0.83 Mtons CO_2e from 1990 to 2005 by the Swedish EPA (Naturvårdsverket 2009). Cederberg et al. (2009a) estimate life-cycle GHG emissions from Swedish animal production to be reduced by 1.2 Mtons CO_2e during this 15-year period. Obviously, when it comes to animal products, increasing trends in consumption-related GHG emissions are in sharp contrast with decreasing production-related emission trends in Sweden. Most striking is the massive increase of emissions caused by the growing meat consumption between 1990 and 2005, corresponding to ~2.3 Mtons CO_2e in absolute numbers and almost 60 % in relative figures (Table 6.1). This strong emission growth is solely caused by increased meat imports and is thus not reported in any official statistics since they only include emissions from domestic production. The magnitude of emission growth is conspicuous when comparing with other sectors. The emission growth caused by increased meat consumption between 1990 and 2005 corresponds to almost 30 % of all GHG emissions in Swedish agriculture in 2005[12] or close to 20 % of all GHG emissions from private cars in Sweden in 2005[13].

Per capita GHG emissions caused by consumption of all meat, milk and egg products increased by more than 16 % and reached approximately 1 100 kg CO_2e per capita in 2005 (Table 6.2); since the Swedish population increased by 460 000 people during the 15-year period, the relative emission increase is lower per capita than total, compare Table 6.1. In 1990, dairy products made up around 50 % of total per capita GHG emissions, but this has changed and meat products, especially beef, are now responsible for a significantly larger proportion of average per capita emission. Besides the growing meat consumption, reduced CFs of dairy products due to a more efficient production in combination with stable consumption levels explain why milk products make up a significantly lower proportion of total per capita emission in 2005 compared with 1990.

Estimated per capita emissions from the Swedish consumption of all animal products here indicate an average increase of approximately 1 % per year between 1990 and 2005, and this despite the fact that the production of animal products in Sweden became more efficient during the studied time period, delivering meat, milk and eggs with lower GHG emissions per produced unit in 2005 compared to 1990 (Cederberg et al., 2009a).

[12] The agriculture sector emitted 8.5 Mtons CO_2e in 2005 according to NIR (SEPA 2009)
[13] Transports with private cars emitted ~12 Mtons CO_2e in 2007 according to Vägverket (Johansson, 2008)

Table 6.2 Per capita GHG emissions (kg CO_2e per cap) from consumption of meat, dairy products and eggs in Sweden 1990 and 2005

	1990, kg CO_2e per cap	2005, kg CO_2e per cap	Change, kg CO_2e per cap	Change, relative
Meat	458	693	+235	+51 %
Dairy	470	382	-88	- 19 %
Eggs	20	20	0	0
Animal products, total	948	1 095	+147	+16 %

Present consumption-related emissions are not sustainable when seen in a global context. To prevent global temperature to rise more than 2°C, GHG atmospheric concentration must be stabilised at 400 ppm CO_2e in 2050; corresponding to total yearly emission of 16-18 Gton CO_2e. With an anticipated world population of 9 billion people in 2050 this would mean an average per capita emission of 2 ton CO_2e in 2050 and at the end of this century <1 ton CO_2e per capita (SOU 2007). In this study, we estimate the emissions from meat-, milk- and egg consumption in Sweden in 2005 at approximately 1.1 ton CO_2e per cap*year and yet, this estimate does not take into account effects of land use changes. This current per capita level in Sweden is more than half of total per capita emission from all consumption of goods and services suggested as an emission target in 2050 and further troublesome, the emission trends have been heading in the wrong direction.

Beef and milk

Production of milk and beef is closely inter-linked as beef primarily has been a by-product from milk production. When dairy cows are culled and slaughtered, meat is produced and the surplus calves (mostly bulls and some heifers not needed for replacing the culled cows) are raised as beef cattle, slaughtered at 1.5-2 years of age.

During the studied time-period, the Swedish dairy population was reduced by 130 000 head (30 %) due to a strong productivity increase; in 1990, the average dairy cow produced 6000 kg milk in comparison with 8000 kg in 2005. From this follows, that less and less beef are produced as a by-product from the dairy sector. In Sweden, this lost production has been compensated by increased beef production in "pure" beef-systems, so-called "cow-calf systems"; characterised by that the mother animals, suckler-cows, solely produce calves to be further raised as beef cattle and no milk for human consumption is delivered. The "cow-calf system" is a low-efficient meat production system compared with pork and poultry since the mother animal only produce one off-spring per year. Also, beef livestock emits methane and must be raised for a much longer time-period than pigs and poultry to reach final slaughter weight, therefore demanding more maintenance feed and producing more manure, all these factors result in higher GHG emissions per kg meat. But there are also benefits; cattle can produce meat on grass solely as opposed to pork and poultry, and some agricultural land is low-yielding grain land not suitable for any other crops than grass. Also, with the right pasture management, grazing livestock have positive effects for biodiversity. In Sweden, the introduction of more suckler-cows (as an effect of a declining dairy cow herd) over the past 15 years has been a necessity for the preservation of the semi-natural grassland area of approximately 500 000 hectares which has amongst the highest biodiversity value in the country and are declared to be maintained as a national environmental quality goal.

As milk yield per dairy cow increases, which is an on-going general trend as a result of e.g. improved genetics, feeding regimes and overall management, there will be less beef produced as a result of by-products from dairy production. The effect is that increased consumer demand of beef must be sourced from "cow-calf systems", being meat production with the highest GHG-emissions per unit produced. Thus, productivity gains in dairy production, leading to a smaller dairy cow population, must be accompanied by an overall reduction of beef consumption, otherwise emission reductions in the dairy sector risk to be "eaten up" if beef instead is to be produced in "cow-calf systems" with high emissions per unit of meat.

Consumption trends

Swedish beef consumption was stable until early 1990s and the upward going trend that followed took place despite the BSE-crisis that had impact on consumption in other EU-countries. Favourable development of

consumer prices is important for this development, e.g. when Sweden became an EU-member in 1995, beef prices were cut by almost 10 % and the subsequent year, a reduction of food VAT probably further fuelled consumption. Also for pork and even more for poultry meat, consumer prices have developed favourable. While general food price index were cut by 2 % from 1990 to 2006, meat prices decreased by 12 % (Board of Agriculture, 2009). Meat has become relatively less expensive than other food products and this is a very probable explanation to the growing meat consumption in Sweden since the early 1990s. The National Food Administration´s present recommendations are 1 portion of meat per day, corresponding 100-120 g meat and 40 g cured meat products. Current consumption is higher than this, and in the newly proposed guidelines, also including environmental aspects, Swedish meat consumption is suggested to be reduced (see note 1).

For dairy products, long term per capita consumption trends show declining milk consumption but increasing cheese consumption which have doubled since the 1960s. Prices on dairy products have followed the general price development of the whole food basket, not becoming relatively cheaper as meat products have. In 2005, total milk consumption corresponded to approximately 355 kg milk per capita[14] which is almost the same as in 1990.

Besides price effects, other factors also are important for the increase in meat consumption. Between 2000 and 2005, consumption of meat in ready meals exploded, from 10 to 17 kg per capita (Board of Agriculture, 2009). Consumer accessibility for meat meals has changed over the 15 year period and it has become easier to buy fast food products like hamburgers and kebabs almost anywhere and anytime of the day. Food waste is yet a factor that can explain some of the increasing meat consumption. In this analysis, we have used statistics on total consumption, which means that household food waste also is also included. There are hardly any Swedish studies of food waste today and we do not have any knowledge whether there is more waste from meat and milk products today than in the early 1990s. Research in England shows that 13 % of edible meat products are not consumed but thrown as waste in households today (Ventour, 2008). It is possible that a larger share of the consumer´s food ends up as waste today, explaining a part of the increased consumption.

In later years, there is a fast growing and wide-spread interest for new diets for weight control. One example is the Low Carbon High Fat diet recommending a food intake that is low in carbohydrates and high in animal fat, another is the Paleolithic diet recommending high intake of for example fruit, nuts and lean meats (but low in dairy products). Characteristic for both these diets is that a large share of total food intake, as gross energy intake, is recommended to be made up of animal food products. As a global average, around 13 % of the food intake today consists of animal food but in the industrialized world this is much higher, approximately 30-33 % (Wirsenius, 2000). If people in the rich world will move towards diets consisting of even more animal food products than is the case today, future targets on limiting average global emission at 2 ton CO_2e per capita will be even harder to reach than is already the case.

In this project we have shown that despite reduced GHG emissions from domestic production of meat, dairy and egg, predominantly consumed in Sweden, consumption-related emissions have still increased significantly due to an increased consumption of imported meat. This leads us to the conclusion that mitigation in food production will not be enough to reach future targets for GHG emissions. Also consumer patterns and food diet trends must be addressed. Price development of animal food is an important factor for consumer behaviour but there are also others; e.g. availability, food preparation methods, “fashion diets”, food waste etc. We conclude that, while there is considerable work undertaken to develop and introduce mitigation in agriculture, there are still considerable knowledge gaps on how to make food consumption more sustainable.

[14] Here, we calculated 10.1 kg milk per kg cheese and 10.5 kg milk per kg milk powder

7 REFERENCES

Arla Foods 2005. Miljöredovisning (Environmental reporting), Arla Foods, Stockholm.

Barker T et al. 2007. Technical Summary. In: Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, B. Metz et al., (eds), Cambridge University Press, Cambridge, United Kingdom and New York.

Berlin J. 2001. Life Cycle Inventory (LCI) of Semi-Hard Cheese. SIK-report 793, The Swedish Institute for Food and Biotechnology, Göteborg.

Board of Agriculture. 2000. Marknadsöversikt – animalier (Market survey – animal food products). Rapport 2000:23, the Swedish Board of Agriculture, Jönköping.

Board of Agriculture. 2006. Marknadsöversikt – animalier (Market survey – animal food products). Rapport 2006:35, the Swedish Board of Agriculture, Jönköping.

Board of Agriculture. 2007. Konsumtion av livsmedel och dess näringsinnehåll (Consumption of food and its nutrient contents). Statistikrapport 2007:2 (korrigerad version 2007-07-13), the Swedish Board of Agriculture, Jönköping.

Board of Agriculture. 2009. Livsmedelskonsumtionen 1960-2006 (Food consumption 1960-2006). Statistiskrapport 2009:2, the Swedish Board of Agriculture, Jönköping.

Board of Agriculture. 2009. SJV statistics over animal production. Sveriges officiella statistik (www.sjv.se => statistik animalieproduktion)
http://www.sjv.se/amnesomraden/statistik/animalieproduktion.4.7502f61001ea08a0c7fff102122.html

Cederberg C, Sonesson U, Henriksson M, Sundh V, Davis J. 2009a. Greenhouse gas emission from Swedish production of meat, milk and eggs 1990 and 2005. SIK-report 793, The Swedish Institute for Food and Biotechnology, Göteborg.

Cederberg C, Meyer D, Flysjö A. 2009b. Life cycle inventory of greenhouse gas emissions and use of land and energy in Brazilian beef production. SIK-report 792, the Swedish Institute for Food and Biotechnology, Göteborg.

Dalgaard R. 2007. The environmental impact of pork production from a life cycle perspective. PhD-thesis, University of Aarhus, Department of Agroecology and Environment, Tjele, Denmark.

LRF 2002. Maten och miljön – livscykelanalys av sju livsmedel (Food and environment – LCA of seven food products). Lantbrukarnas Riksförbund, LRF, Stockholm.

McMichael A J, Powles J W, Butler C D, Uauy R. 2007. Food, livestock production, energy, climate and health. *Lancet*, published online September 13 2007. DOI:10.1016/S0140-6736(07)61256-2

Nguyn T L T, Hermansen J, Mogensen L. 2009. Environmental performance analysis of EU beef. Submitted article

SEPA 2009. National inventory report 2009 Sweden – Submitted under the United Nations Framework Convention on Climate Change and the Kyoto Protocol. The Swedish Environmental Protection Agency, Stockholm.

Sevenster M & de Jong G. 2008. Global, regional and life cycle facts and figures on greenhouse gas emissions. DELFT CE. www.ce.nl

Sonesson U, Cederberg C, Flysjö A, Carlsson B. 2008. Livscykelanalys av ägg (Life Cycle Assessment of eggs). SIK-report 783, the Swedish Institute for Food and Biotechnology, Gothenburg.

SOU. 2007. Vetenskapligt underlag för klimatpolitiken (The scientific base for climate policy). Miljövårdsberedningens rapport 2007:03, Vetenskapliga rådet för klimatfrågor, Miljövårdsberedningen, JO 1968:A. Statens Offentliga utredningar, Stockholm.

Ventour L. 2008. The food we waste. WRAP, Branbury, UK. http://www.wrap.org.uk

Weidema B P, Wesnaes M, Hemansen J, Krsitensen T, Halberg N (Eder P and Delgado Eds). 2009. *Environmental Improvement Potentials of Meat and Dairy Products*, EUR 23491 EN – Joint Research Centre – Institute for Prospective Technological Studies, EU, 2008

Wirsenius S. 2000. Human Use of Land and Organic Materials. Modeling the Turnover of Biomass in the Global Food System. Department of Physical Resource Theory, Chalmers University of Technology, Göteborg.

PERSONAL COMMUNICATION

Donis, M. 2008. Svensk Fågel, Stockholm.

APPENDIX 1) SUMMARY OF CONSUMPTION, PRODUCTION, IMPORT AND EXPORT OF ANIMAL PRODUCTS, 1000 TONNES (KG PER CAPITA) IN SWEDEN 1990 AND 2005. ALL MEATS ARE WITH BONE.

1000 tonnes (kg per capita)	1990				2005			
	cons	**prod**	**imp**	**exp**	**cons**	**prod**	**imp**	**exp**
milk products [1)]	1345 (157)	1357 (159)	n/a n/a	n/a n/a	1270 (141)	1257 (139)	32.9 [2)] (3.6 [2)])	21.4 [2)] (2.4 [2)])
cream	77.3 (9.0)	77.3 (9.0)	n/a n/a	n/a n/a	89.2 (9.9)	89.2 (9.9)	[3)] [3)]	[3)] [3)]
cheese	133.5 (15.6)	115.7 (13.5)	21.8 (2.5)	4.0 (0.5)	160.4 (17.8)	118.2 (13.1)	58.4 (6.5)	16.2 (1.8)
butter fat	43.8 [4)] (5.1 [4)])	75.8 [5)] (8.9 [5)])	n/a n/a	32.0 [6)] (3.7 [6)])	30.5 [4)] (3.4 [4)])	44.5 [5)] (4.9 [5)])	5.3 [6)] (0.6 [6)])	19.3 [6)] (2.1 [6)])
milk powder	28,7 (3.4)	57,6 (6.7)	2.4 (0.3)	31.3 (3.7)	22.1 (2.4)	48.5 (5.4)	8.5 (0.9)	34.9 (3.9)
egg	117 (13.7)	122 (14.3)	11 (1.3)	16 (1.9)	115 (12.7)	101.5 (11.2)	39.6 (4.4)	26.1 (2.9)
poultry meat	50.4 (5.9)	49.1 (5.7)	1.5 (0.2)	0.2 (0.02)	150.3 (16.6)	106.9 (11.8)	54.9 (6.1)	12.4 (1.4)
beef (including veal)	148.1 (17.3)	145.3 (17.0)	12 (1.4)	12 (1.4)	231.2 (25.5)	135.9 (15.0)	105.8 (11.7)	11.8 (1.3)
pig meat	262 (30.6)	291 (34.0)	16 (1.9)	39 (4.6)	324.0 (35.9)	275.1 (30.5)	81,0 (9.0)	36,0 (4.0)
mutton and lamb	6.6 (0.77)	4.9 (0,57)	1.5 (0.18)	0.035 (0.004)	10.7 (1.2)	4.1 (0.45)	6.6 (0.73)	0.52 (0.06)
horse meat	3.2 (0.37)	1.9 (0.22)	n/a n/a	n/a n/a	1.5 (0.17)	1.0 (0.11)	0 0	0 0
game and reindeer meat	26.3 (3.1)	n/a n/a	n/a n/a	n/a n/a	19.8 (2.2)	n/a n/a	n/a n/a	n/a n/a
others (intestines etc)	18.2 (2.1)	n/a n/a	n/a n/a	n/a n/a	10.0 (1.1)	n/a n/a	n/a n/a	n/a n/a

[1)] consumption milk and soured products
[2)] including cream
[3)] included in milk products
[4)] own calculations: production+import-export
[5)] including butter oil and butter fat in mixed products
[6)] only butter, i.e. excluding butter oil and butter fat in mixed products

Source: Board of Agriculture (2000; 2006) and the Internet
http://www.sjv.se/amnesomraden/statistik/animalieproduktion.4.7502f61001ea08a0c7fff102122.html

APPENDIX 2) SOURCES FOR INDATA FOR POST-FARM ACTIVITIES

Product	**Trp to food industry**	**Processes at food industry**	**Trp to retailer, Stockholm**
Pork, Swe	LRF 2002* (both years)	LRF 2002* (both years)	Assumed distance, 500 km truck
Pork, imp Denmark 2005	Dalgaard et al (2008)	Dalgaard et al (2008)	Assumed distance 100 km boat, 600 km truck
Poultry meat, Swe	LRF 2002* (both years)	LRF 2002* (both years)	Assumed distance, 500 km truck
Poultry meat, imp Denmark 2005	www.lcafood.dk	www.lcafood.dk	Assumed distance 100 km boat, 600 km truck
Beef, Swe	LRF 2002* (both years)	LRF 2002* (both years)	Assumed distance, 500 km truck
Beef, imp EU 2005	LRF 2002	LRF 2002	Assumed distance, 1250 km truck
Beef, imp Brazil	Cederberg et al 2009b	Cederberg et al 2009b	Cederberg et al 2009b
Fresh dairy products, Swe	1990: LRF (2002)* 2005: Arla Foods (2005)	Arla Foods (2005; 1996)	Assumed transport, 200 km truck
Cheese, Swe	1990: LRF (2002)* 2005: Arla Foods 2005	1990: Berlin 2001 2005: Arla Foods (2005)	Assumed distance, 500 km truck
Milk powder	1990: LRF (2002)* 2005: Arla Foods (2005)	Arla Foods (2005; 1996)	Assumed distance, 500 km truck
Eggs, Swe	Sonesson et al 2008	Sonesson et al, 2008	Assumed distance, 360 kg truck (Sonesson et al 2008)
Eggs, imp Fin	Sonesson et al 2008	Sonesson et al, 2008	Assumed distance, 200 km truck, 250 km boat

* Around 2000, there was an LCA-project analyzing seven major food items (milk, beef, pork, chicken meat, bread, potatoes, lettuce) where transports to and processes at food industry were investigated quite thoroughly. Data from this project were used for both years, since we assume that there are quite small differences in 1990 and 2005 compared to the situation around 2000 when these data were collected.

APPENDIX 3) RESULTS

	Total, Ton CO_2e				Per capita, Kg CO_2e/cap			
	1990	2005	Diff	Change	1990	2005	Diff	Change
Meat								
Pig meat	1 084 680	1 160 652	75 792		126	128	2	
Poultry	138 278	354 827	216 549		16	39	23	
Beef	2 709 624	4 756 110	2 046 486		315	526	210	
Total meat	**3 932 582**	**6 271 589**	**2 339 007**	**58%**	**458**	**693**	235	**52%**
Egg	171 990	178 230	6 240		20	19,7		
Total egg	**171 990**	**178 230**	**6 240**	**4%**	**20**	**19,7**	**-0,3**	**-2%**
Dairy products								
Fresh	1 863 213	1 468 196	-395 017		217	162	-55	
Cheese	1 775 550	1 740 760	-34 790		207	192	-14	
Milk powder	401 800	249 730	-152 070		47	28	-19	
Total dairy products	**4 040 563**	**3 458 686**	**-581 877**	**-14%**	**470**	**382**	**-88**	**-19%**
Total animal products	**8 145 135**	**9 908 505**	**1 763 370**	**22%**	**948**	**1 095**	**147**	**16%**