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Project information

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Internal report for Oatly AB

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Summary

Life cycle assessment (LCA), according to ISO 14040, has been conducted on two of Oatly's basic products: natural, enriched aseptic oat drink and fresh oat drink to provide specific and quantitative environmental information about these products. The aim is to increase the understanding of the environmental impact of oat drinks and show where the greatest impact occurs. This will be used as a tool in the improvement process internally at Oatly, as well as contributing to the environmental data of oat drink production.

The project has been carried out by SIK AB, the Swedish Institute for Food and Biotechnology, on behalf of Oatly AB. The life cycle assessment has undergone an independent external audit.

The functional units in this study are:

- Oat drink plain aseptic, in consumer packaging (1 litre), for consumption at home by the consumer.
- Oat drink plain fresh, in consumer packaging (1 litre), for consumption at home by the consumer.

Both products are made from conventionally grown oats. The study covers the life cycle of the oat drinks, including the consumption by the consumer (including disposal of packaging by the consumer). A comparison with the environmental impact of 1 litre of semi-skimmed milk is also included as part of the project.

The data used in the study consists mostly of specific data gathered from personal contacts (email and phone) and visits to Oatly production plant. The inventory has been coordinated internally at Oatly by the project's contact person Linda Eriksson (development engineer), and SIK has also made use of previously conducted life cycle assessments (particularly for milk) and the literature data from previous studies.
Data quality in this study can be considered sound and representative of the system.

The study shows that both of the Oatly oat drink types have a lower environmental impact than semi-skimmed milk. This can be explained by the fact that milk production is a more complex process, including the feeding of animals, management of manure and methane emissions associated with animal rumination. The table below summarises the overall results of the environmental impact of one litre of aseptic oat drink, one litre of fresh oat drink and one litre of semi-skimmed milk.

Environmental Impact	**Aseptic oat drink**	**Fresh oat drink**	**Milk**	**Unit**
Impact on climate	0.4	0.5	1.3	kg CO2 eq
Primary energy	7.7	9.2	19.6	MJ eq.
Soil eutrophication	0.005	0.006	0.103	mol N eq.
Freshwater eutrophication	0.00010	0.00019	0.00008	kg P eq.
Marine eutrophication	0.002	0.002	0.006	kg N eq.
Acidification	0.002	0.002	0.024	mol H+ eq.
Tropospheric ozone	0.001	0.002	0.004	kg NMVOC eq.
Land use	0.6	0.6	2.9	m^2
Water consumption	0.0005	0.008	0.0009	m^3 of water eq.

Pink indicates the greatest environmental impact of the drinks within the same impact category.

The results also show that there are many different activities in the life cycle that contribute to the environmental impact of the drinks and emphasise the importance of addressing environmental issues from a holistic perspective. The different stages in the life cycle have varying degrees of environmental impact depending on the impact category.

Conclusions:

- The study shows that Oatly oat drinks have a lower environmental impact than semi-skimmed milk.
- The life cycle assessment shows that with the current production set-up (with the fresh drink production in Germany) that, from an environmental perspective, the aseptic drink is preferable to the fresh drink. If the production of the fresh drink would take place in Sweden instead (with the same process parameters, but with the Swedish ratio), the results would have been different and the distinction between the aseptic and fresh drinks would have been small.
- The plant in Landskrona is a hotspot for the production of the aseptic drink with regards to impact on climate, energy and water consumption.
- The plant in Germany is a hotspot for the production of the fresh drink in terms of impact on climate, energy and water consumption, and freshwater eutrophication.
- Climate contribution from transport accounts for about a third of the total climate contribution from oat drinks, with a slightly greater contribution from the fresh product. This is partly because the fresh drink has longer transport times and that this transport is refrigerated.
- Home transport, that's to say the private transport made by the consumer, has the greatest environmental impact.
- The transport from Oatly to wholesale gives a relatively large negative contribution to the environment and should be analysed in more detail.
- Contribution to climate from cold storage (after production) of the fresh oat drink is marginal.
- There is potential for improvement in both the aseptic and fresh oat drink production processes.
- The environmental impact of the aseptic drink packaging is larger than that of the fresh drink packaging.

CONTENTS

INTRODUCTION

Background

Working towards sustainable production and reducing the environmental impact of its products and production processes have now become a key issue for many food producers. Both the global environmental impact of climate change and local impacts such as eutrophication are important to consider. Climate change is undoubtedly a crucial issue and has therefore become an important area for politicians and businesses. As the issue is given much attention in the media, it increases awareness among business customers and individual consumers that their choice of products such as foodstuffs directly affects greenhouse gas emissions and other environmental impacts.

At the industrial level, many companies have started setting goals for reducing their environmental impact. Today, it's also clear that companies are expected to have knowledge about environmental impact and assume responsibility for what takes place outside the factory gates, in other words to consider the impacts on environment and climate from, for example, raw materials and transport.

Life Cycle Assessment (LCA) is a methodology that takes information from the entire system, from
cradle to grave, i.e. from raw material production to waste management. This provides an understanding of where in the chain environmental impacts occur, and shows where environmental improvement measures have the greatest impact. The analysis gives quantitative results of the environmental impact, and the LCA method can therefore be used, for example, if quantitative environmental goals are set for a product or parts of the production system.

Life Cycle Assessment method

In this study, the method of life cycle assessment (LCA) is applied to analyse and quantify the environmental impact of the products. The different phases of an LCA are

- definition of the study's scope and objectives
- inventory analysis
- environmental impact assessment
- interpretation of results

The framework of the LCA methodology is standardised according to the ISO standard ISO 14040 and ISO 14044 (ISO 2006a & ISO 2006b) and is shown in Figure 1. The work methodology used to conduct an LCA is iterative, which means that the content and scope may change during the course of the work.
In the study's *scope and objectives*, the goals, purpose and limitations are also defined. Moreover, the functional unit (FU) is also defined. The FU is the calculation basis that all the results are related to. In the scope and objectives section, the system boundaries are also defined and the flows which are excluded are stated.
Inventory analysis, in other words the collection and processing of data, is often the most time-consuming part of an LCA study. In the inventory phase, all the input flows (e.g. energy and materials) and output flows (e.g. by-products and emissions) shall be identified and quantified.

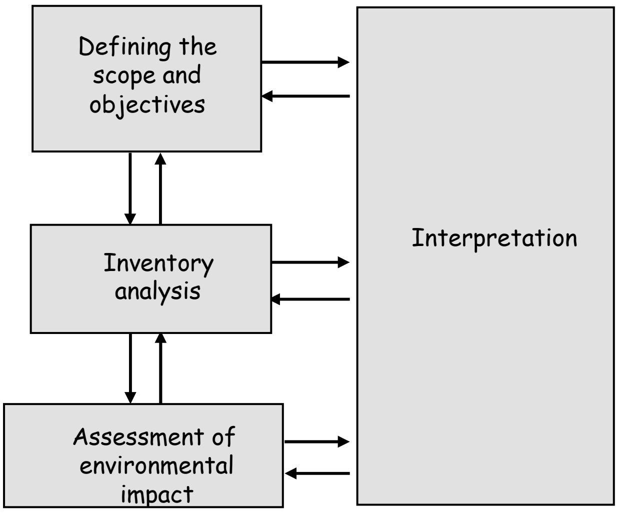


Figure 1. Workflow in an LCA according to ISO 14040

The purpose of the *environmental impact assessment* is to analyse and assess the environmental impact of all the input flows that have been identified in the inventory analysis. The first step in the environmental impact assessment is classification, whereby different types of resources and emissions are sorted and grouped into the environmental impact category that they affect e.g. greenhouse gases in the climate change category and eutrophying substances in the eutrophication category. The second step is the characterisation. In this phase, the relative distribution of each emission within each environmental impact category is assessed. For example, in the climate change category, each individual greenhouse gas is measured according to its impact in that category. Greenhouse gases are thus treated as the same unit (carbon dioxide equivalents), so that it's possible to add them up. Then, the result of each individual greenhouse gas can be added up and we get the result of the entire system's impact on climate change.

In the final *interpretation*, conclusions are drawn from the analysis on the basis of the conditions that have been set up in the scope and objectives section. This phase may also include a discussion of the study's data quality and/or a sensitivity analysis of selected substeps in the life cycle.

The main purpose of an LCA is, above all, to acquire knowledge about the product's life cycle and to find out exactly which substeps in the life cycle have the greatest environmental impact, in order to be able to optimise the environmental work.

The computer software used for the life cycle assessment is SimaPro 7 (PRé, 2008).

SCOPE AND OBJECTIVES

The purpose, scope and objectives of the study

The goal of the project is to carry out a life cycle assessment (LCA) of two of Oatly's basic products; aseptic oat drink and fresh oat drink, in accordance with ISO 14040, to provide specific environmental information about these products. A comparison of the environmental impact of 1 litre of semi-skimmed milk is also included as part of the project.

Environmental impact categories include energy consumption, impact on climate, eutrophication (over-fertilisation), acidification, formation of tropospheric ozone, and land use. The accumulated water consumption - that's to say all the water that's supplied to the product during the life cycle (not rain) - will also be specified, as well as a qualitative description of pesticide use in oat cultivation.

The aim is to increase knowledge of the environmental impact of the oat drinks and demonstrate where the greatest environmental impact occurs. Another function of the study is to use the results as a tool in improvement work internally at Oatly and also in consumer relations and the marketing of an active environmental profile of Oatly's oat drinks.

The data for the environmental impact of milk is mainly based on a previously completed LCA study (Cederberg et al, 2009) of milk. The stage which follows the farm level is modelled in this report.

Commissioning body

The project has been carried out by SIK AB, the Swedish Institute for Food and Biotechnology, on behalf of Oatly AB.

Description of the products

The two products which were selected for the study are plain (unflavoured) aseptic and fresh oat drinks (1 litre). Both are based on conventionally cultivated oats and are fortified with calcium and vitamins.

They specifically chose these products on the grounds that they were typical of the consumer-packaged goods in the Oatly range and it would be interesting to study the difference between the fresh production chain (including cold storage) and the aseptic one (stored at room temperature in unopened packaging). The fresh drink produced partly in Schwerin, Germany, means longer transport times. The fresh oat drink is produced mainly for consumers in Sweden, while the aseptic drink is also exported to Finland, Norway and the UK. Both products are sold in regular grocery stores. The project assumes an average Swedish consumer as the end user of all products.

The production of the fresh oat drink from the oat base is carried out at the Oatly plant in Landskrona, with further transport and production of the finished fresh oat drink in Germany. Throughout this report, "oat base" refers to the base from which the fresh drink is made.

Functional unit

The functional unit constitutes the study's basis and shall reflect the product's benefits, as well as being practically measurable. The functional units in this study are:

- oat drink plain aseptic in consumer packaging (1 litre), for consumption at the home of the consumer.
- oat drink plain fresh, in consumer packaging (1 liter), for consumption at the home of the consumer.

Scope of the study

The study includes the oat drinks' life cycle, including consumption by the consumer (which includes disposal of packaging by the consumer). Figure 2 and Figure 3 provide an overview of the input substeps in the life cycle, even if the respective substeps in turn consist of a processing tree and contain intermediate transport. Each part of the chain includes emissions and resource consumption from its respective part of the system.

The first step in the life cycle is the production of food raw materials/ingredients which are used in the Oatly production plant. Oat cultivation is followed by the processing of the oats into groats (hulled oat kernels) as the main ingredient in this case, even though other ingredients are present in small flows. Other input materials include the production of packaging material, as well as processing aids such as chemicals. The next step is the transport of ingredients/packaging/processing aids to the Oatly plant. The third step is Oatly's own production of aseptic oat drink. The system finishes by dealing with the wholesale, retail and consumer levels, as well as the intermediate transport.

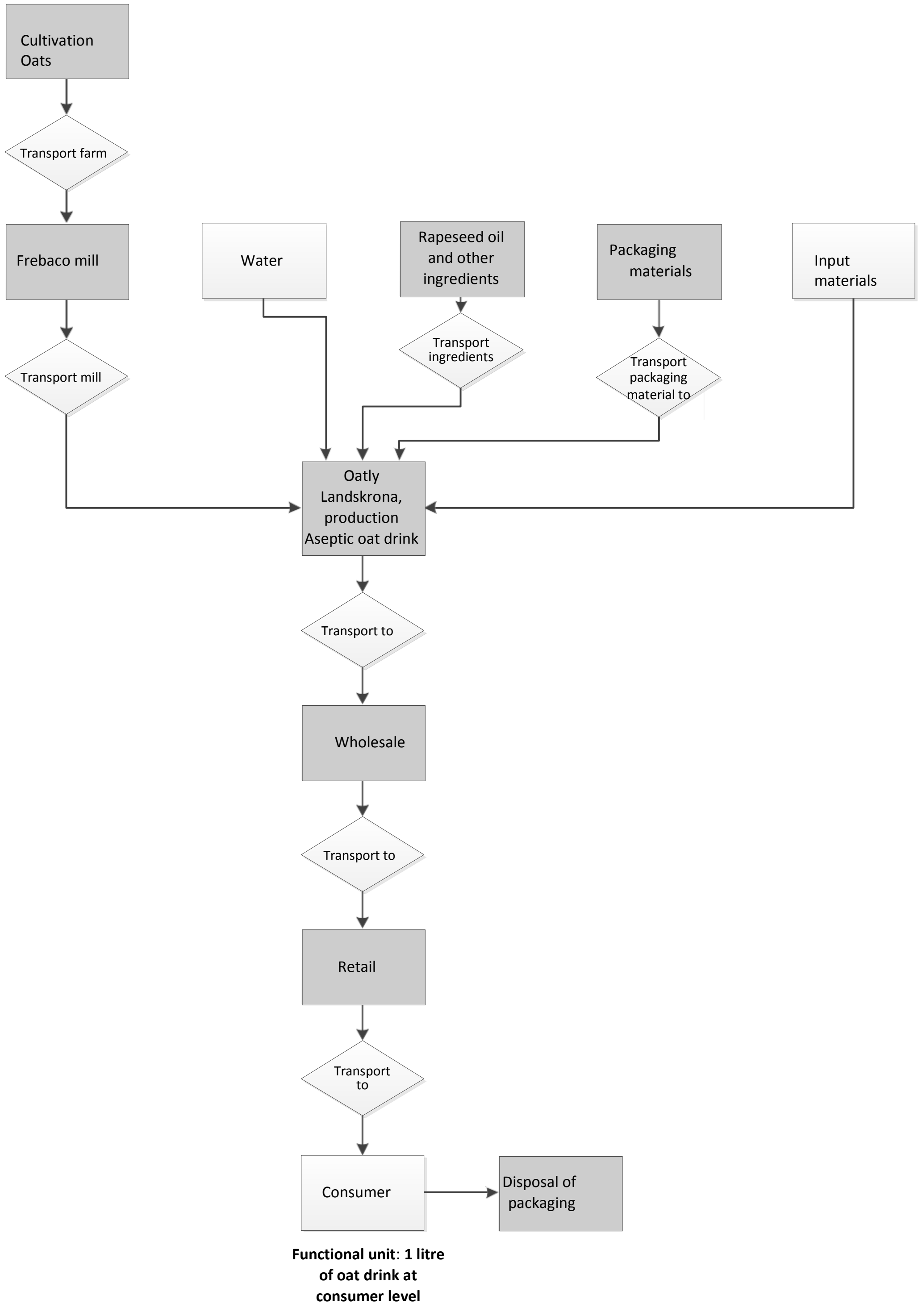
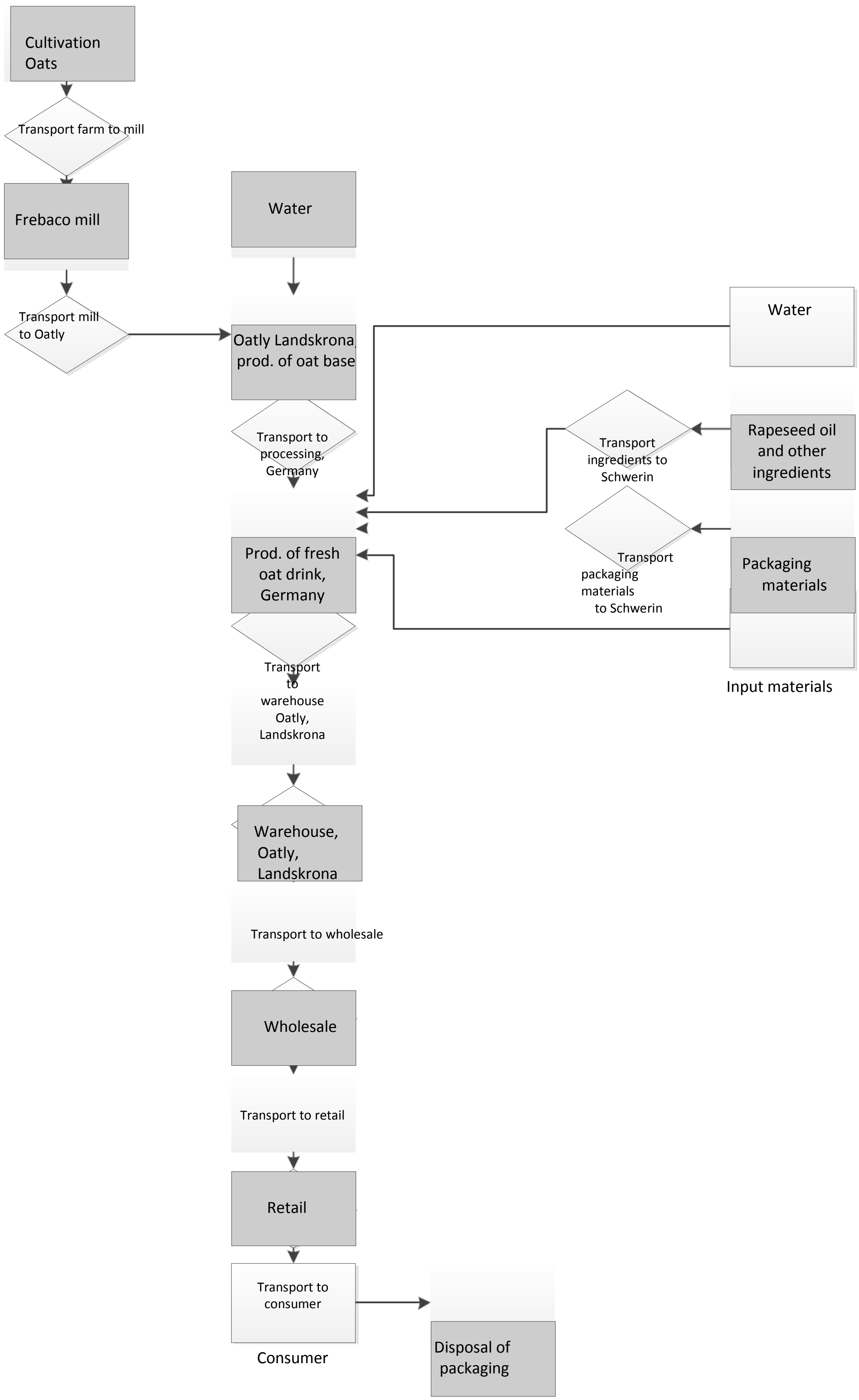


Figure 2: Flowchart 1 litre aseptic oat drink including consumer. The process steps marked "transport" relate to transport within the system.

The scope of the system for the fresh oat drink is partially the same as for the aseptic. What distinguishes the two is that, at the Oatly plant in Landskrona, an oat base with a higher DM content than the aseptic oat drink is produced and is then transported to the plant in Germany for further processing and packing of the fresh oat drink. Thereafter, the fresh oat drink is transported back to Landskrona for the same distribution as the aseptic drink, however it includes the addition of refrigerated transport.



Functional unit: 1 litre of fresh oat drink at consumer level

Figure 3: **Flowchart 1 litre fresh oat drink including consumer**. **The process steps marked "transport" relate to transport within the system.**

The milk system used in the comparison between oat drink and milk has been modelled so that the system boundaries are set in the same way as for the oat drink, that is, from primary production to consumer, Figure 4. Data for the primary production of milk (with all input materials and inflows to the dairy farm such as feed, fertilisers etc.) are taken from a previous report (Cederberg et al, 2009). The dairy, packaging and transport to retailers have been modelled to represent an average milk chain. Transport to the consumer and disposal of packaging by the consumer are the same as for oat drink.

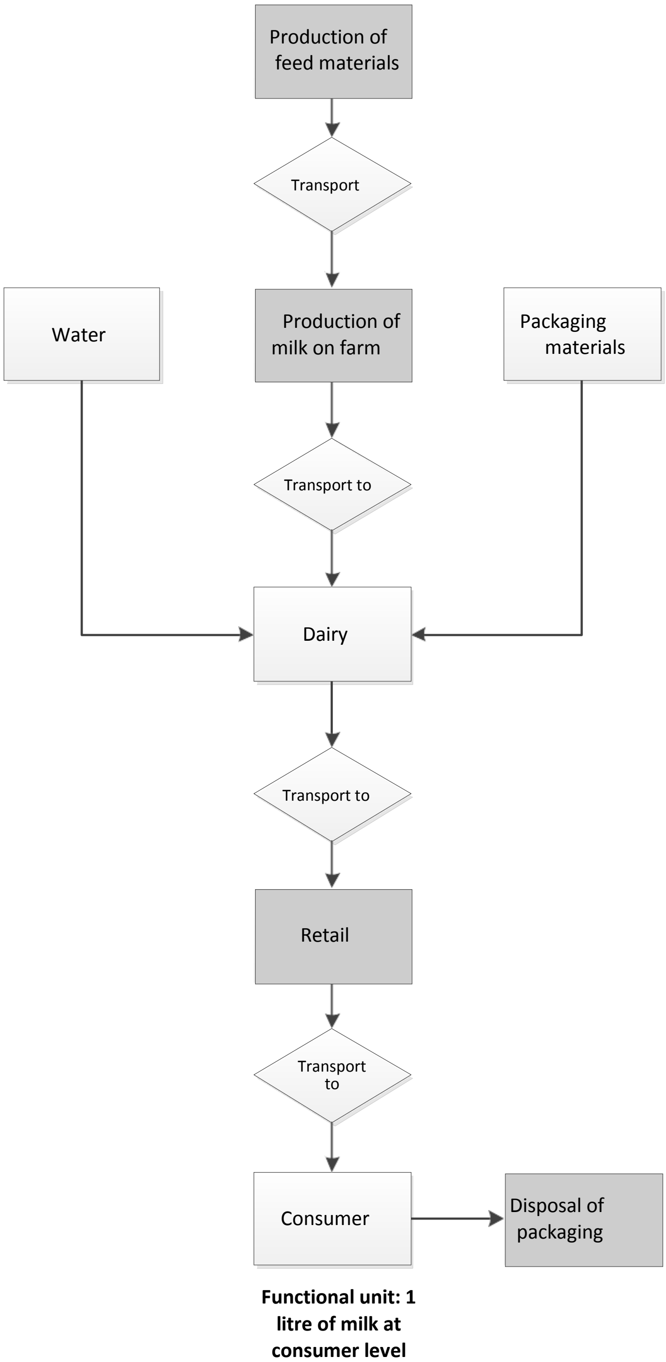


Figure 4: **Flowchart for 1 litre milk including consumer. The process steps marked "transport" relate to transport within the system.**

Data collection and data quality

The data used in this study originate from different sources. Mainly through direct data collection from personal visits to the Oatly plant, personal contact through phone calls and emails with staff at Oatly AB via the project's contact person Linda Eriksson (development engineer), and also: previously performed LCAs at SIK; values from Ecoinvent's database; data presented by the professional transport calculation tool NTM Calc3; and literature data from previous studies. Data quality in this study can be considered sound and representative of the system. Specific information about the data sources that have been used is described in the inventory chapter.

When it comes to the milk production data, we know from experience that it is the primary production data that is of greatest importance for the environmental impact of milk. Primary production data used in the report (Cederberg et al, 2009) is based on data from SCB (Statistics Sweden) and SJV (Swedish Board of Agriculture) and corresponds to the data from Sweden's milk production in 2005.

Allocation and system expansion

In the LCA context, allocation means the distribution of environmental impacts and resource requirements between products in a production system that generates more than one product.
Allocation situations arise when, for example, as in many production plants, more than one product is produced in the manufacturing process or when we get several products from a raw material (ISO 2006a,b). In this study, allocation will only be used in the few cases where it was not possible to distribute certain inflows of input materials and emissions between the oat base, aseptic oat drink and other production in Landskrona, as well as the products produced at the German plant in Schwerin.

One can allocate core values as a base. According to the ISO standard, allocation on a physical basis is preferable to a division based on the economic value of the products (economic allocation). In cases where allocation has been applied in Landskrona, the environmental impact has been distributed on the basis of the amount of incoming oats required for the aseptic oat drink and the oat base. This is to encompass the difference in the fact that the oat base is a more concentrated product than the aseptic oat drink. At the plant in Germany, mass allocation is applied in some cases for the distribution of the plant's impact to the fresh oat drink.

In terms of allocation between meat and milk for those animals that also produce milk in the life cycle assessment of milk, the division has been made in a physical manner (Cederberg et al, 2009). The allocation is based on the amount of feed required for milk production and meat production.

Whenever possible, system expansion is preferred to allocation according to the ISO standard. With system expansion, the intention is to subtract an equivalent amount of residual by-product from one's own system. What is of greatest importance with system expansion is what is selected as a substitute for one's own system. In this study, system expansion has been applied in connection with the production of biogas from the contents of the packaged products at the plant in Landskrona (damaged, unsold or withdrawn for quality control).
The products from the Oatly plant are likely to substitute the production of an equivalent amount of energy natural gas.

System expansion has also been applied in connection with the raw material wastage, known as oat fibre slurry, which is being used as pig feed. These flows are based on the energy, protein and amino acids contents adopted to substitute the alternative feed materials with a corresponding nutritional function.

System expansion has also been included in the combustion of primary packaging in that the energy produced is likely to substitute the alternative production of Swedish district heating and Swedish electricity.

Limitations of the study

What is omitted from the study due to the project's framework regarding the objective and time scale is indicated as limitations in time and space. As a definition of the limitations, the omissions have been specified.

Time

Data from Oatly used in the study represents the production year 2012. For the other ingredients used in the oat drinks, the most recent available data (from different years) of good quality is used; the same applies to transport and energy.

As for the milk study, the data represents Sweden's milk production in 2005.

Geography

In most cases, Swedish inventory data has been used for the ingredients of the oat drink. In cases where Ecoinvent data has been used, it is considered to be representative of Europe. Selection of the data described in the inventory chapter.

Machinery, buildings and infrastructure

Infrastructure (such as the contribution for the construction and maintenance of roads) is included in the background data which is taken from the Ecoinvent databases. This applies to data for packaging materials, energy and transport. Contributions from maintaining Oatly machinery and buildings are not included in the study and neither is infrastructure for the other parts of the study.

Staff

Staff travel to and from work, lunches, uniforms etc. have not been included in the calculations.

Ingredients

Inventory data is missing for a few ingredients. They have therefore been excluded from the system. As these ingredients have very small flows, this does not affect the result significantly. Ingredients that have been excluded are enzymes and vitamins.

In some cases, substitute data has been used to represent specific ingredients. These assumptions are described in the inventory chapter.

Inputs

The production of the synthetic refrigerant R407C used at the plant in Landskrona is not included in the study. However, the leakage of refrigerant is included as an air emission (Environmental Protection Agency (Sweden, 2012).

The incoming transport of chemicals and inputs are not included in the analysis.

Packaging

The incoming shipments of tertiary packaging material (transport packaging such as stretch film) are not included in the analysis.

Outputs to nature

Solid waste from the plants has not been followed all the way back to nature. That is to say the emissions from the production of packaging materials at the Oatly plant, recycling and incineration has been excluded from the study. The size of these outputs represent less than 0.2% (m/m) of the production at the Oatly plant in Landskrona.

The environmental impact of the recycling of carton and corrugated paper packaging is not included in the calculations. The system has been defined so that the user behind the recycled raw materials should also carry responsibility for the environmental impact.

For the treatment of wastewater going from the plants to the municipal water treatment works, specific purification degrees for nitrogen, phosphorus, BOD and COD from Gryaab's treatment works in Gothenburg have been used (Gryaab, 2012). Contribution from resource use in the purification process is not included.

The comparison basis

The functional unit for the study and the basis for comparison is the volume (1 litre) of drink. No comparisons based on the nutrient content of the drinks are included.

General assumptions of the study

Some process steps for the production in Germany (sterilisation, washing and storage) have been calculated using corresponding values from the plant in Landskrona, but with the German plant's own energy sources.

An unopened package of the aseptic drink has not been charged with cold storage, because it does not require refrigeration, even if some shops/wholesalers choose to handle it as a chilled product.

There is no specific information about the details on losses in the latter part of the chain after the products have left the production plants. Details on losses have been assumed at retail level (the same quantity for all products), while no details on losses have been included in the calculations at wholesale and consumer levels.

For the assumptions concerning the types of transport from the production plant and the distances covered, the same conditions have been applied to all products (specific information in the inventory chapter), but including a refrigerant levy on the transport of fresh oat drink as well as milk.

Critical review

The report has undergone an external independent peer review carried out in four stages during the project. The review was conducted by Johanna Berlin at SP Technical Research Institute. The review report in its entirety can be found in appendix 5.

DATA INVENTORY

Data inventory on Oatly oat drink has been done according to the standard for conducting a life cycle assessment (ISO 14040).

Inventory information is divided and presented below as follows:

- Inventory data on the aseptic oat drink produced in Landskrona and the fresh oat drink produced in Landskrona and Germany.
- Inventory data on Swedish milk production.

Unless otherwise stated, details on the environmental impact of energy production and fuel combustion have been taken from the Ecoinvent database. All transport values have been estimated using the background data from the Network for Transport Measures as a basis (NTM, 2012). The production of diesel is taken from the Ecoinvent database and also from information on infrastructure (production and maintenance of roads and vehicles). In cases where refrigerated transport applies, a refrigerant levy of 1.3 has been added to the transport in order to estimate the additional fuel consumption required to operate the refrigerating units.

For the milk that the oat drinks are compared to, the starting point is based on existing data from SIK's environmental database (SIK Food Database), as well as literature. To make the products comparable, the latter stages in the chain for milk (distribution-retail-consumer) have been calculated with the same type of modelling as for the oat drink.

ASEPTIC AND FRESH OAT DRINK

Data for raw materials, energy, wastage, emissions to air and water, as well as waste management, has been inventoried for each part of the oat drinks' life cycle. In this chapter, the inventoried data is described quantitatively, along with documentation of the methods used and any assumptions. Alternatively, data sources from where information is taken are referenced. Unless otherwise specified, the input data collected by Oatly has been with the help of its suppliers (Eriksson, 2013).

The substeps are the same at the beginning of the life cycle, but later, when the life cycles of the aseptic and fresh oat drinks separate, the results are reported in parallel in corresponding subchapters.

Oat cultivation

The cultivation of the oats used in Oatly oat drinks takes place at Varaslätten. Information on the cultivation parameters of importance for environmental impact has been collected from Varaslättens Lagerhus (Varaslätten's Warehouse) (Samuelsson, 2013). In those cases where data has not been inventoried from Varaslätten's warehouse, these parameters have been taken from other oat cultivation in west Sweden as presented in SIK's feed database (www.sikfoder.se). Table 1 summarises the data on resource consumption and emissions to air and water, while some of the data is used as a basis for calculating air emissions. The data marked in bold is specifically inventoried for oat cultivation at Varaslätten.

Table 1: Input for oat cultivation

Input for oat cultivation	Amount
Crop yield, tonnes	**5.5**
Area, m2	10,000
Seeds, kg	180
Diesel, litres	**76**
Lubricating oil, kg	**6.4**
Water content before drying	0.18
Water content after drying	0.13
Oil, drying, litres	**50**
Electricity, drying, kWh	**145**
Mineral fertiliser, kg P	**20**
Mineral fertiliser, kg K	**20**
Mineral fertiliser, kg N	**100**
Manure, tonnes	0
Crop residues, kg N	**53**
Direct N2O emissions	
kg N2O	**2.8**
Indirect N2O emissions	
kg N2O	**0.55**
N leaching, kg N	45
N leaching, kg NO3	199
P leaching, kg P	0.56
Ammonia emissions mineral fertiliser, kg	**1.2**
Ammonia emissions, kg NH3	**1.5**
Pesticides	
Weeds (not glyphosate), g as	**592**
Fungus, g as	**75**
Insect, g as	**0**
Glyphosate, g as	**270**

Direct and indirect emissions of nitrous oxide (N_2O) are estimated according to the IPCC recommendations, which are specific values because they are based inter alia on the additional nitrogen through manure and in crop residues (IPCC, 2006).

Data of nitrogen and phosphorus leaching into water has been estimated on the basis of literature data on the standard leaching for crops, regions and soil types (Environmental Protection Agency Sweden 5823). Data of nitrogen in crop residues is calculated according to the IPCC (Tier 1). 12% of the aerial crop residues (straw) were salvaged - a detail received from Adolfsson (2005).

Ammonia emissions from mineral fertilisers were calculated as 1.2% of the additional nitrogen, as recommended by the European Environment Agency (EMEP/EEA, 2009).

Transport of oats to Frebaco mill

For the transport of oats from field to mill, a heavy truck with trailer (40 tonnes maximum load) has been used with a 90% weight-based load capacity and a transport distance of 36 km.

Frebaco mill

The mill receives the unhulled oats where they are cleaned and hulled. Thereafter they are prepared and dried, after which they are hulled and ready for loading. The hulled oats in production.

Table 2 shows the input data representing the total production of oats on grainline 1 of the mill in 2012. Energy for offices and other non-process-related operations are not included. Oatly uses a total of 2600 tonnes of hulled oats in its production.

Table 2: Inputs for the processing of oats at Frebaco mill

Input	*Amount*	*Comment*
Oat production	10,255 tonnes	Hulled oats
Electricity consumption	654,830 kWh	100% hydroelectricity
Oil, fuel oil 1	287 m^3	35.8 GJ/m^3
Water	3100 m^3	
Oat remnants	1550 tonnes	13.5% DM, for feed
Oat hulls	4350 tonnes	10% DM, for feed

The environmental benefits given by oats fractions to feed have been calculated in the same way as oat fractions to pig feed at the Oatly plant. For a detailed description, read the section entitled system expansion.

Water

For water used at the Oatly plant in Landskrona (in the product, for washing and rinsing, as well as for cooling), the SimaPro resource process for water from Sweden has been applied (Water, unspecified natural origin, SE)

Rapeseed oil and other ingredients

Other ingredients used in Oatly aseptic and fresh oat drink are rapeseed oil, calcium carbonate, tricalcium phosphate, dicalcium phosphate, salt (sodium chloride), enzymes and vitamins. The amounts of each are stated in the recipes shown in the section on production at the Oatly plant in Landskrona. For some ingredients, substitute data has been used in the absence of other information. Due to the small amounts of these ingredients, this assumption has a negligible environmental impact.

Rapeseed oil

Data for rapeseed oil represents Swedish production from 2010 and is taken from SIK's environmental database.

Additives and functional ingredients

The combined share of the ingredients listed below make up less than 0.5% of the drinks and the impact is probably negligible. Specific inventory data has not been obtained, however data for equivalent or similar products has been obtained from Ecoinvent or SIK Food databases.

Calcium carbonate

Data is missing for food grade calcium carbonate, however it has been substituted by the Swiss data on calcium carbonate ($CaCO_3$) (Limestone, milled) from Ecoinvent.

Tricalcium phosphate and dicalcium phosphate

Inventory data for tricalcium phosphate and dicalcium phosphate is missing, however it has been substituted by the data on monocalcium phosphate from Ecoinvent's database.

Salt

Data for salt (sodium chloride) is taken from the Ecoinvent database and corresponds to European production.

Enzymes and vitamins

As inventory data on enzymes and vitamins is missing, it has not been included in this study. However, enzymes and vitamins constitute only a small percentage of the products, 0.01% and 0.002% respectively, and their exclusion is unlikely to have an impact on the final results.

Packaging

The two oat drinks have two different primary packagings, Figure 5. This is mainly due to the fact that the aseptic drink requires an oxygen barrier (aluminum film) to obtain the desired shelf-life.

Figure 5. Packaging for the aseptic oat drink to the left and for the fresh oat drink to the right.

The aseptic liquid packaging carton, Table 3, which is manufactured in Sweden and has specific transportation (distances and loading capacities) for incoming shipments of packaging materials to the plant in Landskrona, has been included in the analysis.

Table 3. Packaging information for aseptic oat drink.

	Materials	Total weight per functional unit (g)
Primary	Liquid packaging carton: Cardboard PE Alu	28.2 of which 22.1 4.7 1.4
	Cap: PE	3.36
Total		**31.56**
Secondary	Paperboard	15.2
Tertiary	PE, top and stretch film	0.26

Liquid packaging carton for the fresh oat drink, Table 4, is manufactured in Italy and the specific transportation (distances and loading capacities) for incoming shipments of packaging materials to the plant in Germany have been included in the analysis.

Table 4. Packaging for fresh oat drink

	Materials	Total weight per functional unit (g)
Primary	Liquid packaging carton: Cardboard PE	31.9 of which 28.4 3.5
	Cap: PE	2.65
Total		**34.55**
Secondary	Paperboard	21.2
Tertiary	PE, stretch film, paperboard	0.31 0.06

Ecoinvent data for the production of liquid packaging carton is used for both packagings (as in for milk carton) but with the addition of the specified amounts of PE, cardboard and aluminium. Country-specific electricity has also been included in the production of the liquid packaging carton.

Incoming shipments to Oatly, Landskrona

The data for incoming shipments of ingredients and packaging materials to Oatly have been inventoried regarding specific truck type, transport distances and loading capacities, Table 5. For those ingredients where vans are used for incoming shipments, a general loading capacity of 50% has been adopted. The environmental impact of empty return transport has been taken into account and modelled with a half capacity load. A 90% loading capacity has been used in the calculations, even in cases where a 100% capacity has been included in the inventory, thereby taking into account the positioning vehicles used before new loading.

Table 5: Summary of incoming shipments to Landskrona

Incoming raw material	Type of vehicle	Loading capacity (%)	Distance (km)
Oats from mill	Heavy truck / semi-trailer (max 25 tonnes	50	361
Rapeseed oil	Heavy truck / semi-trailer (max 25 tonnes load)	20	167
Calcium carbonate	Heavy truck / semi-trailer (max 25 tonnes load)	50	577
Tricalcium phosphate & dicalcium phosphate	Heavy truck / semi-trailer (max 25 tonnes load)	50	44
Salt	Heavy truck / semi-trailer (max 25 tonnes load)	50	237
Aseptic packaging	Heavy truck / semi-trailer (max 25 tonnes load)	90	918
Plastic cap for aseptic	Heavy truck / semi-trailer (max 25 tonnes load)	50	33
Trays	Heavy truck / semi-trailer (max 25 tonnes load)	50	32

Production of aseptic oat drink and oat base at Oatly, Landskrona

Aseptic oat drink

General information

Reception of hulled oat kernels via the bulk container truck. The hulled oats are stored in oat silos. They then undergo wet milling, enzyme treatment and the separation of insoluble oat fibres. The insoluble fibres are diluted slightly to create oat fibre slurry, which is pumped into a container and then goes to the pig farmer as feed. Ingredients are added to the remaining liquid - the oat base - for the production of the aseptic oat drink. Thereafter, the liquid undergoes UHT treatment (at 140°C) and is poured into the aseptic packaging.
The packaged product is put on trays which are then put on pallets. The pallets are wrapped with film and placed in the warehouse at room temperature.

A total of 18,787 tonnes was produced at the plant in 2012, 25% of which was the aseptic drink (4,756 tonnes).

Energy

At the plant, both electricity and natural gas are used as energy sources for production. Sweden's average electricity consumption is used for calculations (which to some extent also include imported electricity). Oatly has specified the energy consumption for each process step that relates to 4,756 tonnes, equivalent to the 2012 production of aseptic oat drink. The division of energy into the various process steps is not reported in detail below, but is available in Appendix 1. The natural gas consumption shown in Table 8 corresponds to the energy derived from natural gas. To calculate the amount of natural gas consumed, a factor of 1.1 has been used following recommendation from the Oatly staff. Specific inventory has been conducted by the Oatly staff for the vast majority of the inventory parameters of the plant's input. This means that in most cases no form of allocation, the distribution of environmental impacts between the products produced at the plant, has been applied.

During the project, Oatly's product storage warehouse was under construction, which means that the data for the warehouse is an estimation and not based on existing data from 2012.

Production of input materials

The production of the cleaning chemical products nitric acid (HNO_3), caustic soda (NaOH) and hydrogen peroxide (H_2O_2) is included, with data from Ecoinvent.

Air and water emissions

For refrigerant leakage and emissions of BOD and COD to water, the plant's total emissions have been distributed with an allocation factor of 35% to the aseptic drink, based on the proportion of incoming oats for the aseptic drink in relation to the total amount of incoming oats to the plant.

Water emissions have also been restated to take into account the degree of water treatment efficiency, that is to say they only include the amounts which, through emissions to water, eventually end up in nature, see Table 6.

Table 6: Water treatment purification levels (GRYAAB, 2012)

Water emissions	Purification levels at the
Ntot	68%
Ptot	94%
BOD	94%
COD	86%

System expansion regarding the by-products and wastage as pig feed and biogas

In connection with production, a by-product of oat fibre slurry is obtained; plus there is wastage incurred in production and rinse waste from the UHT treatment. These are collected and set aside for pig feed. The nutritional and energy values of oat fibre slurry are provided in Appendix 2. According to feed advisors, 1kg of oat fibre slurry has the same feeding function as 0.39kg of soya and 0.84kg of oats (Susanne Bååth Jacobsson, VÄXA), where all values are calculated as 100% dry matter. Wastage incurred in production as well as drainage as a result of UHT treatment are assumed to be modelled in the same way. Environmental benefits from the production of feed are taken into account through system expansion, whereby the environmental impact from a residual by-product equivalent to the amount of soya and oats are removed from our system. Inventory data for the production of the feed products - soya and oats - are taken from the SIK feed database (www.sikfoder.se).

In connection with production, there are also withdrawals and rejects of the finished packaged product (via quality control, unsold, and damaged product). These flows go to biogas production. System expansion has been carried out for the amount of methane produced in biogas, where it is assumed to replace fossil natural gas. The amount of methane produced is calculated from the handbook on bioactive substrates "Household food wastage sorted by source - milled & diluted (10% DM)", where 38 m^3 of methane is produced per tonne of wet weight, with an energy value of 39.8 MJ per m^3 of methane. 20% of the amount of biogas produced is used up in the process (Berglund, 2012)

Excluded flows

Water treatment is only included through the inclusion of the purification levels. The energy to power a treatment plant, the energy created during the digestion (sewage) and the resulting chemical precipitation are all excluded from the analysis.

The disposal of solid waste generated at the Oatly plant is also excluded from the analysis. In relation to total production, the amount of solid waste accounts for less than 0.15%.

Quantities of ingredients

The recipe in Table 7 shows the ingredient amount per kg of product. The values for the food flows in Table 7 have been adjusted upwards by a factor of 1.01 (about 1%) to take into account product wastage which goes to the production of biogas.

Table 7: Quantities of ingredients used in aseptic oat drink

Ingredient	Amount per kg of product (kg)
Water	0.91
Oat groats	0.13
Dry oat fibre removed	-0.02
Water removed	-0.033
Rapeseed oil	0.008
Calcium carbonate	0.002
Tricalcium phosphate	0.001
Dicalcium phosphate	0.0005
Salt	0.001
Enzyme (excluded)	*0.0001*
Vitamin (excluded)	*0.00002*
Total:	0.99962

Summary of the inventory data for aseptic oat drink production at the Oatly plant

Table 8 summarises data on the inflows and outflows used in the modelling and the calculations for the production of aseptic oat drink at the plant in Landskrona.

Table 8: Input data for the processing of aseptic oat drink at Oatly, Landskrona

Input	Amount	Comment
Production Aseptic oat drink	4,756 tonnes	
Electricity consumption	643,907 kWh	Average Swedish electricity
Natural gas	1,543,331 kWh	Specified as resulting energy
Water for cooling,	20,900 m3	
cleaning, rinsing	14,400 m3	
Oat fibre slurry	43,949 kg	100% DM, for pig feed
Raw material wastage	30,188 kg	10% DM, for pig feed
Withdrawals, controls and rejects	42,948 kg	10% DM
Nitric acid HNO_3	11,477 kg	53% concentration
Lye NaOH	10,184 kg	50% concentration
Hydrogen peroxide	2,150 kg	35% concentration
Refrigerant R407C	0.25 kg	Air emissions, average over 4 years,

		allocated value of factor 0.35
Ntot	555 kg	Emissions to water, water treatment included
Ptot	3.96 kg	Emissions to water, water treatment included
BOD	1,370 kg	Emissions to water, water treatment included, allocated with 0.35
COD	5,760 kg	Emissions to water, water treatment included, allocated with 0.35

Fresh oat base

General information

As for the production of the fresh oat base, which is the main ingredient of the fresh oat drink, the process is largely the same as for the production of the aseptic drink in Landskrona. Except for the final steps (including the UHT treatment) which are different and take place in the production of the fresh oat drink in Schwerin, Germany. The methodology behind the calculations and the sources used is therefore the same as the one described in the above section on aseptic drink. Shown here is only the specific data which is different in terms of the recipe and for the inventory data. The fresh oat base has a dry matter content of 14%. It is transported to the plant in Germany for further production, where the other ingredients are added.

1,350 tonnes of oat base was produced in 2012 for the fresh oat drink, which corresponds to 7.2% of the total production in tonnes in Landskrona.

For BOD and COD emissions, the plant's total emissions have been distributed with an allocation factor of 13% for the oat base for the fresh drink, based on the proportion of incoming oats that go to making the oat base for the fresh oat drink in relation to the total amount of incoming oats.

Quantities of ingredients

The recipe in Table 9 shows the amount of ingredient added per kg of oat base.

Table 9: Quantities of ingredients used to make the fresh oat base

Ingredient	Amount per kg oat base (kg)
Water	0.89
Oat groats	0.18
Dry oat fibre removed	-0.027
Water removed	-0.043
Total:	1.0

Summary of the inventory data for the production of fresh oat base at the Oatly plant

As with the aseptic oat drink, the vast majority of the inventory parameters have been developed specifically for the oat base and are based on the production of fresh oat drink in 2012, equating to 1,350 tonnes.

Table 10 summarises data on the inflows and outflows used in the modelling and the calculations for the production of oat base for the fresh oat drink at the plant in Landskrona.

Table 10: Input data for the production of oat base for the fresh oat drink at Oatly, Landskrona

Input	Amount	Comment
Production oat base	1,350 tonnes	
Electricity consumption	59,272 kWh	Average Swedish electricity
Natural gas	69,173 kWh	Specified as resulting energy
Water for cooling	4,320 m3	
Water for cleaning, rinsing	2,820 m3	
Oat fibre slurry	35,910 kg	100% DM, for pig feed
Nitric acid HNO3	1,629 kg	53% concentration
Lye NaOH	1,445 kg	50% concentration
Ntot	110 kg	Emissions to water, water treatment included
Ptot	0.78 kg	Emissions to water, water treatment Included
BOD	510 kg	Emissions to water, water treatment included, allocated with 0.13
COD	2,140 kg	Emissions to water, water treatment included, allocated with 0.13

Incoming shipments to the plant in Schwerin (Germany)

Input data for incoming shipments of ingredients and packaging materials to the plant in Schwerin has been inventoried, and specifically with regards to truck type, transport distances and loading capacities, Table 11. For other ingredients (not the oat base), there has been varied transportation, therefore a vehicle with a maximum loading weight of 25 tonnes has been adopted with a general loading capacity of 50%, while the distances are specific.

The environmental impact of empty return transport has been considered and modelled with a half load capacity. A 90% loading capacity has been used in the calculations, even in cases where a 100% capacity has been included in the inventory, thereby taking into account the positioning vehicles used before new loading.

Table 11: Summary of incoming shipments to Landskrona

Incoming raw material	Type of vehicle	Loading capa	Distance (km)
Oat base from Oatly	Heavy truck / semi-trailer (max 25 tonnes	90	434
Rapeseed oil	Heavy truck / semi-trailer (max 25 tonnes load)	50	860
*Calcium carbona*te	Heavy truck / semi-trailer (max 25 tonnes load)	50	314
*Tricalcium phosphat*e & *dicalcium phosph*ate	Heavy truck / semi-trailer (max 25 tonnes load)	50	900
Salt	Heavy truck / semi-trailer (max 25 tonnes load)	50	675
Gable top packaging *incl. caps*	Heavy truck / semi-trailer (max 25 tonnes load)	90	1,979
Trays	Heavy truck / semi-trailer (max 25 tonnes load)	50	76

Production of fresh oat drink at the plant in Schwerin (Germany)

General information

The production of fresh oat drink takes place at the German plant in Schwerin. The total production at the German plant was 23,000 tonnes in 2012, at which time the fresh oat drink accounted for 7% of the production volume in tonnes (1,690 tonnes).

It has not been possible to obtain the same level of information on the inventory data for the German plant as for the Oatly plant in Landskrona. In the cases where data was missing, substitute data from Oatly's plant in Landskrona has been used. In Germany, production takes place in batches with a capacity of 6 tonnes per hour. Inventory data for the German plant has been restated so that all data corresponds to Oatly's total production of 1,690 tonnes.

Energy

Electricity and natural gas are used as energy sources at the German plant as well, and the power consumption has been specified as the aggregate energy consumption of the entire plant. Only specific figures for the energy consumption at the warehouse, laboratory and office have been specified. Energy consumption (electricity and gas) for specific steps in production has been estimated using data from Oatly, but the environmental impact is calculated based on the German average (Ecoinvent). See Appendix 1.

The natural gas, as shown in Table 13, is assumed to correspond to the amount of energy derived from natural gas. It has not been possible to obtain the energy figures for natural gas specified as resulting energy or consumed energy. Therefore we have calculated the amount of resulting energy according to the figures for the Landskrona plant. To calculate natural gas consumption, a factor of 1.1 has been used in accordance with recommendation from the Oatly staff.

Water

For water used at the Schwerin plant (in the product and for washing/rinsing), the SimaPro resource process for water from Germany has been applied (Water, unspecified natural origin, DE)

Production of input materials

The production of the chemical products nitric acid (HNO_3), caustic soda (NaOH) and hydrogen peroxide (H_2O_2) is included, with data from Ecoinvent. The amounts are calculated by mass allocation, whereby the fresh drinks account for 7% of the plant's total consumption.

Air and water emissions

There is no data for air and water emissions. However, as there should be water emissions from the wastewater stream, figures for the treatment of the plant's wastewater (73,000 tonnes) have been calculated with an allocation factor of 7% and estimated according to Ecoinvent's data for a general water treatment works.

System expansion regarding "by-products/waste" into biogas

In connection with production and even after the drink has been packaged, wastage and rejections/withdrawals are estimated at 3.3% of the production. These flows go to biogas production. System expansion has been carried out for the amount of methane produced in biogas, where it is assumed to replace fossil natural gas. The amount of methane produced is calculated from the handbook on bioactive substrates "Household food wastage sorted by source - milled and diluted (10% DM)", where 38m^3 of methane is produced per tonne of wet weight, with an energy value of 39.8 MJ per m^3 of methane and where 20% the produced amount of gas is consumed in the process (Berglund, 2012).

Excluded flows

Even the disposal of solid waste generated at the Schwerin plant and the system expansion for this have been excluded from the analysis. In relation to total production, the amount of solid waste accounts for less than 0.5%.

Quantities of ingredients

The recipe in Table 12 shows the amount of ingredient per kg of product. The values for the food flows in the table have been adjusted upwards by a factor of 1.03 to take into account the additional raw material consumption due to product wastage which goes to the production of biogas.

Table 12: Quantities of ingredients used in fresh oat drink

Ingredient	Amount in kg, fresh oat drink (kg)
Water	0.274
Oat groats	0.713
Rapeseed oil	0.008
Calcium carbonate	0.002
Tricalcium phosphate	0.001
Dicalcium phosphate	0.0005
Salt	0.001
Enzyme (excluded)	*0.0001*
Vitamin (excluded)	*0.00002*

Total:	1.00

Summary of inventory data for fresh oat drink production at the plant in Schwerin.

Table 13 summarises data on the inflows and outflows used in the modelling and calculations for the production of fresh oat drink at the Schwerin plant.

Table 13: Input data for the processing of fresh oat drink at the plant in Schwerin

Input	Amount	Comment
Production fresh oat drink	1,690 tonnes	
Electricity consumption	193,525 kWh	Average German electricity
Natural gas	448,946 kWh	Specified as resulting energy
Water for cooling,	2,347 m3	
cleaning, rinsing	5,110 m3	
Waste flow to biogas	56,770 kg	Approx. 10% DM
Nitric acid HNO3	1,120 kg	53% concentration
Lye NaOH	3,290 kg	50% concentration
Hydrogen peroxide	377 kg	35% concentration
Refrigerant leakage	0 kg	
Ntot	5,110 tonnes	Water to wastewater treatment

Transport of fresh oat drink from Schwerin to Oatly in Landskrona

For the transport of fresh oat drink from the Schwerin plant to Oatly in Landskrona, a heavy truck/semi-trailer (25 tonnes max load) has been used with a 90% weight-based loading capacity and a transport distance of 434 km. The temperate transport from Schwerin to Landskrona has been adjusted upwards by a factor of 1.3 to account for the operation of the refrigerating unit.

Storage duration and shelf-life of the oat drinks

The two oat drinks have different shelf-lives and storage durations vary according to the different stages in the chain, Table 14. Storage durations are based on data from Oatly. The aseptic drink is stored at room temperature, except for the last 7 days when it's assumed it is stored in a refrigerator. For the fresh drink, the use of refrigeration is included at every stage in the chain.

Table 14: Storage durations at the different stages in the chain.

Storage duration	Fresh (days)	Aseptic (days)
Germany	6	-
Landskrona (average storage durations for 2012)	12	43
Wholesale	7	14
Retail	7	28
Consumer	7	14*
Total duration:	**39**	**99**
Total shelf-life (Specified on the package)	***50***	***365***

* assuming 7 days at room temperature and 7 days at refrigeration temperature

Energy consumption at wholesale, retail and consumer levels

The energy consumption through cold storage in the later stages of the chain (after factory) are taken from the background data that was developed in conjunction with the work on the report "Impact on climate caused by the refrigeration chain from agri-food production to consumer" (Nilsson et al., 2011), a study performed by SIK in collaboration with SP, on behalf of SLV, Table 15. Swedish electricity has been used as the energy source. An assumption has been made on energy consumption during storage at room temperature to 10% of the energy consumed by refrigeration.

Table 15: Energy consumption through cold storage in the later stages of the chain

Storage place in the chain	Energy consumption (Wh/litre and day)
Wholesale warehouse	0.62
Retail	1.32
Consumer	1.94

At retail level, a 0.4% wastage has been assumed for both oat drinks and milk, which is based on the average dairy wastage at retail level (Eriksson and Strid, 2011). At wholesale and consumer levels, no wastage has been included in the calculations because the factual information is missing.

Distribution to wholesale and retail outlets

Both the fresh and aseptic oat drinks are stored at the Oatly plant in Landskrona prior to distribution to wholesale. The distance from the plant to the wholesaler has been assumed to be 477 km. The distance is taken from the climate assessment basis for transport (Klimatmärkningen [Climate Labelling], Report 2010: 1) and is based on a weighted transport distance between a manufacturing plant in Skåne and a wholesaler. A heavy truck with trailer (40 tonnes maximum load) has been used with a 90% weight-based loading capacity and for the fresh oat drink, a 30% refrigerant levy has been added to the transport.

For transport between wholesale and retail, a distance of 64 km has been used (Klimatmärkningen [Climate Labelling], Report 2010: 1) with a refrigerant levy on the transport of the fresh oat drink. A heavy truck with trailer/semi-trailer (25 tonnes max load) has been used with a 50% weight-based loading capacity.

Home transport and the consumer

For home transport - the private transport by car made by the consumer - a distance of 5.46 km has been used. This distance is taken from the Travel Habits Survey 2011 (RVU 2011).
62% of purchases are fulfilled by car (personal communication with Andreas Holmström, Traffic Analysis). We have assumed that one buys an average of 10 kg of goods, including 1 litre of drink which constitutes 10% of the load. Inventory data for a passenger car is taken from Ecoinvent and represents an average car fleet from 2010.

SEMI-SKIMMED MILK

General information on the inventory data for Swedish milk.

The LCA results of the two oat drinks is compared with the LCA result of milk (1.5% fat, semi-skimmed). No new inventory has been made for the milk system and the results are based on the SIK report 793 and represent Swedish milk production for 2005, up to and including the farm. For the dairy and the later stages in the chain, data collection has been based on literature data, environmental reports and assumptions. A brief description of the milk system is given below.

Milk production including the farm

The primary data source for the inventory data for milk production is national statistics from SCB (Statistics Sweden) and SJV (Swedish Board of Agriculture). As this was not sufficient for certain parameters, data from consultancy firms, literature and businesses within agriculture and food was also used. This data provides the result for Sweden's average production of milk (with 4% fat content) in 2005.

Allocation of the environmental impact between milk and meat is based on a physical relationship, which includes the food intake requirements for a cow to produce milk, to live and breed. 85% of the environmental impact is allocated to milk and 15% to meat. For detailed information on the consumption of input materials, feed, fertilisers used in feed production, estimates of emissions, etc., refer to the SIK report 793 (Cederberg et al, 2009). Data for phosphorus and potassium use in connection with feed production and water were not included in the SIK report, but the inventory documentation that came in connection with the report has been used here.

For information on phosphorus and potassium use in the cultivation of feed materials, please refer to the SIK feed database (www.sikfoder.se).

Water consumption in animal farming

For the estimation of water consumption in animal farming, information has been obtained from the advisors at the Rural Economy & Agricultural Society Halland (personal communication with Carin Classon). Included in Table 16 are drinking water, wastewater, and water used for washing/cleaning. 85% of water consumption per animal is allocated to the milk.

Table 16: Water consumption per cow on the farm

	Drinking water (l/day and animal)	wastewater and washing/cleaning water (l/day and animal)
Dairy cows	80	14
Recr. Heifers' milk >1 year	35	1
Recr. Heifers' milk <1 year	20	1

The Dairy

All information about the dairy chain is taken from environmental reports (2011) on Arla's four largest dairies for the production of milk, sour milk and yoghurt (Daily Fresh Products), Table 17.

The level of detail in the inventory data is not as great as for the corresponding stage in oat drink production, therefore assumptions for the data from the dairy have been made. Four of the selected dairies produce mainly consumer milk and only a small percentage of other products such as fermented milk products and cream (not butter, milk powder or cheese), and therefore we assume that the production on these dairies should apply to the production of consumer milk and cream. A weighted mean value with regards to the production volume from each respective dairy has been used as energy data for "a dairy". Even the volume of wastewater and the amounts of nitrogen, phosphorus and BOD in it are taken from the environmental reports.

Table 17: Consumption of resources at dairies with primarily dairy farming.

Dairy	Total of whole milk (tonnes/ year)	Waste/feed milk (tonnes/ year)	Energy (MWh /year)						Water (m3/year)
			Electricity	Oil	Gas	Vapour	Natural gas	District heating	
Jönköping	222,900	16,300*	15,400	11	7,800			4,050	224,300
Stockholm	227,251	10,381	28,564						257,946
Linköping	196,628	29,262	22,506	5,259		29,659		10,712	647,127
Gothenbur	106,805	8,208	12,696				16,312		283,686

* Not specified in the environmental report, therefore the amount is assumed on the basis of the amounts of feed milk produced at the other three dairies.

In three of the four dairies, only ammonia is used as a refrigerant in the refrigerating units, and the leakage (refill amount during one year) is added. At the fourth dairy, 5 kg CHC (R134a) has been refilled during the year.

Consumption of the most used cleaning agents (nitric acid and caustic soda) are included, but without the incoming shipments of these. Other input materials have not been included in the analysis.

By including energy consumption, wastewater and emissions to wastewater, as well as management of the major by-products, we have covered the environmental impacts of the dairy.

Water

For water used at the dairies for washing and rinsing, the SimaPro resource process for water from Sweden has been applied (Water, unspecified natural origin, SE)

Allocation between milk and cream

The milk (whole milk) arriving at the dairies has a fat content of 4% and the semi-skimmed milk we're interested in has a fat content of 1.5%. The excess fat from the milk (2.5%) is used to make cream. 97.5% of the dairy's resource consumption and emissions have therefore been allocated to milk and 2.5% to cream.

System expansion regarding dairy "by-product" to pig feed

As a diary by-product, an amount of feed milk is obtained (from waste milk) which is a high quality feed for pigs. According to feed advisors, 1 kg of whole milk has the same feeding function as 0.5 kg of soya and 0.4 kg of vegetable oil (Susanne Bååth Jacobsson, VÄXA), where all the values are calculated as 100% DM. The environmental benefit from the production of feed is taken into account by system expansion, whereby the environmental impact from a residual by-product equivalent to the amount of soya and rapeseed oil are removed from our system. Inventory data for the production of soya is taken from the SIK feed database (www.sikfoder.se) and rapeseed oil from the SIK Food database.

Some waste from the dairies goes to biogas production, but this is not included in the analysis.

Transport from farm to dairy

A distance of 300 km for the transport of milk from farm to dairy has been used. The distance has been adopted by Arla and is used as the average transport distance between farm and dairy. It is taken from Arla's Environmental Report 2004 (Arla Foods 2004).

Milk packaging

The primary packaging for semi-skimmed milk is a gable top carton with a plastic screw cap, Table 18. The data for Tetra Pak's Tetra Rex has been used. As incoming shipments of packaging material to the dairy are not known, they have been excluded. The contribution from the transport of packaging material is small, hence its impact on the overall result is likely to be small.

Table 18: Primary packaging for 1 litre of semi-skimmed milk.

	Material	Total weight per functional unit (g)
Liquid packaging carton:		30, of which
	PE	4.5
	Cardboard PE	25.5
Cap:		3

In the distribution of milk, the milk is packed at the dairies and loaded onto cases/trolleys, then loaded directly onto vehicles and distributed to stores. These cases are reused and not included in the analysis. No secondary or tertiary packaging is therefore included for milk.

Shelf-life of milk

Arla indicates that they have a nine-day shelf-life for milk after the dairy. We have assumed that this figure is distributed as follows: one day at the dairy, two days at the store and six days with the consumer.

Energy consumption at wholesale, retail and consumer levels

The energy consumption for cold storage in the later stages of the chain is the same as that for the oat drink, see Table 15.

Distribution from dairy to retailer

After the dairy, milk is distributed in a refrigerated van directly to the retailers. A general distance of 238 km has been adopted. The distance is half the distance specified as the transport distance between production plant and wholesaler in the background report on the impact of transport on climate (Klimatmärkningsprojektet [The Climate Labelling Project], Report 2010:1).
This distance is assumed to be representative, as dairies are spread out around the country and have local distribution. A 40-tonne truck with a 70% loading capacity is used and a refrigerant levy of 30% has been added to the transport.

Home transport and the consumer

The same transport as for the oat drink has been adopted: car transport from the store to the consumer's home.

Assessment of environmental impact

Description of selected environmental impact categories

When conducting a life cycle assessment, data from the inventory and emissions should be attributable to different environmental effects. This part of the life cycle assessment is called classification. It is important to note that a substance emission may give contributions to several different environmental impact categories.

The choice of environmental impact categories made here is based on their importance in relation to food production. They cover environmental impacts which arise from primary production, processing and transport.

Characterisation is a way of ascribing a potential contribution from specific substances or emissions to a particular environmental impact. To do this, it is required that the contribution from emissions are converted to a common unit. This is done by multiplying the emission amounts in the inventory results for a substance with specific characterisation factors for these substances. The contribution from different substances is represented by a common unit that is specific to each environmental effect, for example the contribution to climate change is given in carbon dioxide equivalents. A substance may give several major contributions to an environmental effect depending on whether the emission is to water or air.

The mapping of energy, water and land use is related to the system's inflows, while the environmental impact categories such as impact on climate, acidification, eutrophication and the formation of tropospheric ozone are related to the system's outflows.
The characterisation factors used in the ILCD 2011 Midpoint version 1.05 method (EUR 25,167) have been used to convert the emissions to emission equivalents for the following environmental impact categories: impact on climate, acidification, eutrophication, tropospheric ozone formation and water consumption. ILCD is a collection method based on different methods for different environmental impact categories. See below for the different impact categories. For land use, CML 2001 (Guinée et al, 2002) has been used. For primary energy consumption, the Cumulative Energy Demand (CED) method (Frischknecht et al, 2003) has been used. All the methods used for system modelling and to calculate the potential environmental impact are found in the software SimaPro (SimaPro, 2007).

Primary energy unit: MJ equivalents

Energy and material are resources, with more or less restricted access. In this study, energy consumption is presented as primary energy consumption. This means that the energy content of all resources consumed to produce energy carriers in the system are included. Energy from the following sources are included in the analysis: fossil fuels, nuclear power, biomass, wind, solar and hydroelectric powers, and geothermal energy. To exemplify, to produce 1 MJ of Swedish "middle electricity", 2.4 MJ equivalents of primary energy (mostly hydroelectric and nuclear powers) are consumed.

Greenhouse effect - climate change unit: CO_2 equivalents

The Earth is heated by insolation(mainly in the wavelength range 0.2-0.4 μm). The heated crust then emits heat radiation in the infrared wavelength range (4-100 μm). This radiation is partially absorbed by gases in the Earth's atmosphere and partially emitted back to the Earth's surface, contributing to global warming. This effect is known as the greenhouse effect. Without this natural

greenhouse effect, the Earth's average temperate would be 33°°C lower than it is today. What we call the greenhouse effect is the increased supply of greenhouse gases caused by human activities which affect the Earth's radiation balance. The climate changes that occur are a result of an increase in the Earth's average temperature, which means that some areas are affected by drought through less precipitation. Sea levels can rise resulting in the flooding of coastal areas. Some ocean currents can change direction, which can radically alter the local climate.
The greenhouse effect is a global environmental effect, i.e. local emissions can spread in the atmosphere, having a global effect. The main emissions that contribute to climate change are carbon dioxide, methane, nitrous oxide (laughing gas) and CFC[1]. Table 19 shows the characterisation factors used in the analysis of these emissions. This means, for example, that the emission of 1 kg of methane (CH_4) gives 25 times as great contribution to climate change as an emission of 1 kg of CO_2.

Table 19 Characterisation indexes for the main greenhouse gases

Parameters	Characterisation index (g CO_2 eq./g)
CO_2	1
N_2O	298
CH_4	25

Source: Forster 2007

Acidification unit: mol H+eq.

In addition to carbon dioxide, the combustion of fossil fuels produces sulphur dioxide and nitrogen oxides. These gases combine with water to form acids.
The acids lower the pH of rainwater, causing the acidification of soil and waterways. The impact of acidifying substances is geographically huge. The majority of Sweden (with the exception of Öland, Gotland and Skåne) is extremely sensitive to acidification due to the limestone deficient bedrock. Acidification affects trees and plant life in a negative way; water with a low pH level triggers toxic quantities of aluminium which reaches lakes and rivers (Grennfelt et al, 1994). Crustaceans, roaches, salmon, mayflies and plankton algae are among those affected. Acidification is a regional environmental effect.
Substances with an acidifying effect include SO_2 (sulphur dioxide), NO_x (nitrogen oxides) and NH_3 (ammonia). The method indicates the change in excess of a critical load of acidifying substances in sensitive areas of terrestrial and freshwater ecosystems. Table 20 shows the main characterisation factors used in the analysis of these emissions.

Table 20 Characterisation index for the main emissions that contribute to acidification

Parameters	*Characterisation index (mol H^+eq./kg)*
SO_2	1.31
NO_x	0.74
NH_3	3.02

Source: Seppälä et al. 2006

[1] CFCs, such as Freon

Over-fertilisation / Eutrophication

In the method to measure the impact of eutrophication, the impacts on water (fresh and marine) and land are also included.

Impacts on freshwater and saltwater, units: kg P eq. and kg N eq.

The eutrophication of water systems is considered in terms of the amount of added substances which leach into these systems. An increased supply of these substances in the water system leads to an increased growth of the different species in the system. The decomposition of organic material in water emissions requires oxygen and is measured as BOD or COD. Air emissions of nitrogen compounds can also contribute to the increase of nitrogen in rivers, because nitrogen compounds return to the soil via rainfall which then partially end ups in waterways. The growth of biomass in waterways in the European system is usually limited to the availability of nutrients in the form of nitrogen or phosphorus. Phosphorus is often the limiting nutrient in lakes, while nitrogen is the nutrient that limits the growth of marine systems. Eutrophication is a regional environmental effect, and the characterisation applies to Europe.
The main substances which contribute to eutrophication are NO_3, NH_3 , as well as emissions of nitrogen and phosphorus to water. See Table 21.

Table 21 Characterisation index for the main emissions that contribute to the eutrophication of water systems

Parameters	*Characterisation index*	*(kg P eq./kg)*	*(kg N eq./kg)*
PO_4		0.33	
NH_3			0.824
NO_3			0.226
N			1
P		1	

Source: ReCiPe version 1.05.

Impact on land unit: mol N eq.

The method indicates the change in excess of a critical load of acidifying substances in sensitive areas of the terrestrial ecosystem. Eutrophication is a regional environmental effect, and the characterisation applies to Europe, Table 22.

Table 22. Characterisation index for the main emissions that contribute to the eutrophication of terrestrial systems.

Parameters	*Characterisation index (mol N eq./kg)*
NH_3	13.5
NO_3	6.53
NO_x	4.25

Source: Seppälä et al. 2006

The formation of tropospheric ozone (photochemical oxidant formation), unit: kg NMVOC eq.

Under the influence of sunlight, elevated levels of ozone are formed in the atmosphere due to increased levels of nitrogen oxides (NO_x) and hydrocarbons in the air. Tropospheric ozone inhibits the growth of plants, especially cultivated ones. Ozone is also the main component of photochemical smog, which contains other harmful photochemical oxidants such as PAN (peroxyacetylnitrate). Various volatile hydrocarbons have different effects on ozone formation. NO_x catalyses the chemical reaction, and the concentration of NO_x in the atmosphere also affects the rate at which ozone formation occurs. Due to the influence of sunlight, levels of ozone (O_3) are higher in summer. Photochemical oxidant formation is a local environmental effect. Method according to van Zelm et al. 2008.

Table 23 shows the main characterisation factors used in the analysis of these emissions.

Table 23: Characterisation index for the main emissions that contribute to tropospheric ozone formation.

Parameters	Characterisation index (NMVOC+ eq./kg)
NMVOC, non-methane volatile organic	1
NO_x	1
NO_2	1
SO_2	0.0811

Water consumption (water resource depletion), unit: m3 of water equivalents

The water in Sweden is not a limited resource, but globally the situation is different. In many countries, freshwater is scarce, and globally there is only a limited amount of freshwater to feed the world's population. Primary production of food often requires a lot of water, so it's important to raise the awareness of water consumption in food production. In this analysis, all the water that is used in the system has been included (except rainwater). Water that vegetation takes from the earth is not included. However, the method looks at water consumption from a geographical perspective and thus, indirectly, the availability of water in a given geographic area, in this case in different countries. For water consumption in Sweden, a characterisation index of 0.00468 is used and for water consumption in Germany, an index of 1.52 (Frischknecht et al, Swiss Ecoscarcity, 2009) indicating that there is an impact approx. 300 times greater for using water in Germany than in Sweden. However, there are certainly local variations within a country, but this is not taken into account in this method.

Land use, unit m^2a

Sweden has large areas of land suitable for grazing and feed production. Currently, there is no shortage of land for livestock grazing; in fact, the situation is somewhat the opposite. Conservationists are worried that there are not enough animals to graze on natural pastures to preserve biodiversity.
If one views land use from a global perspective, the situation is different, as overall we have a limited area on which to produce enough food for the world's population. Competition for land exists regarding use of land for food production, biofuel production, and other uses such as construction/buildings.

Use of pesticides

No toxicity assessment has been conducted. The use of pesticides in oat cultivation is discussed in the text.

RESULTS AND DISCUSSION

General information

Below we present the results of the environmental impacts that occur **in the whole chain from farm to consumption of one litre of drink at consumer level, including packaging.** The distribution of the environmental impacts that occur during the drink's life cycle is reported to get an idea of where environmental impact is greatest, and to identify potential for improvement. In the results, both which activities in the life cycle and which emissions contribute most to respective environmental effects are discussed. The results are reported separately for each of the three drinks, followed by a comparison.

The results show that there are several activities which contribute to the environmental impact of the drinks, thereby highlighting the importance of viewing the environmental issues from a holistic perspective. Moreover, which parts of the life cycle have most weight vary according to which environmental effect is being studied; this can make future improvements difficult.

Aseptic oat drink

In the results, the substeps in the life cycle of the aseptic oat drink have been divided as follows:

- Oat cultivation
- Transport farm to mill
- Mill
- Prod. ingredients
- Incoming shipments of ingredients/packaging
- Production of Oatly packaging
- Production of Oatly drink
- Transport Oatly to wholesale
- Wholesale
- Transport wholesale to retail
- Retail
- Home transport
- Consumer

The total environmental impact of aseptic drink is presented in Table 24, while the distribution between the different phases is presented in Figure 7.

Table 24: Environmental impact of aseptic oat drink, 1 litre

Environmental impact	Results	Unit
Impact on climate	0.37	kg CO2 eq.
Primary energy consumption	7.66	MJ eq.
Soil eutrophication	0.0046	mol N eq.
Freshwater eutrophication	0.00010	kg P eq.
Marine eutrophication	0.0022	kg N eq.
Acidification	0.0015	mol H+ eq.
Formation of tropospheric	0.0011	kg NMVOC eq.
Land use	0.57	m^2
Water consumption	0.00054	m^3 of water eq.

As an example of where in the chain environmental impact occurs, a breakdown of the chain in relation to impact on climate of aseptic oat drink is shown below, Figure 6. The data sources used here and the corresponding information on the distribution for other environmental effects throughout the chain, as well as for fresh oat drink and semi-skimmed milk, can be found in the table in Appendix 4.

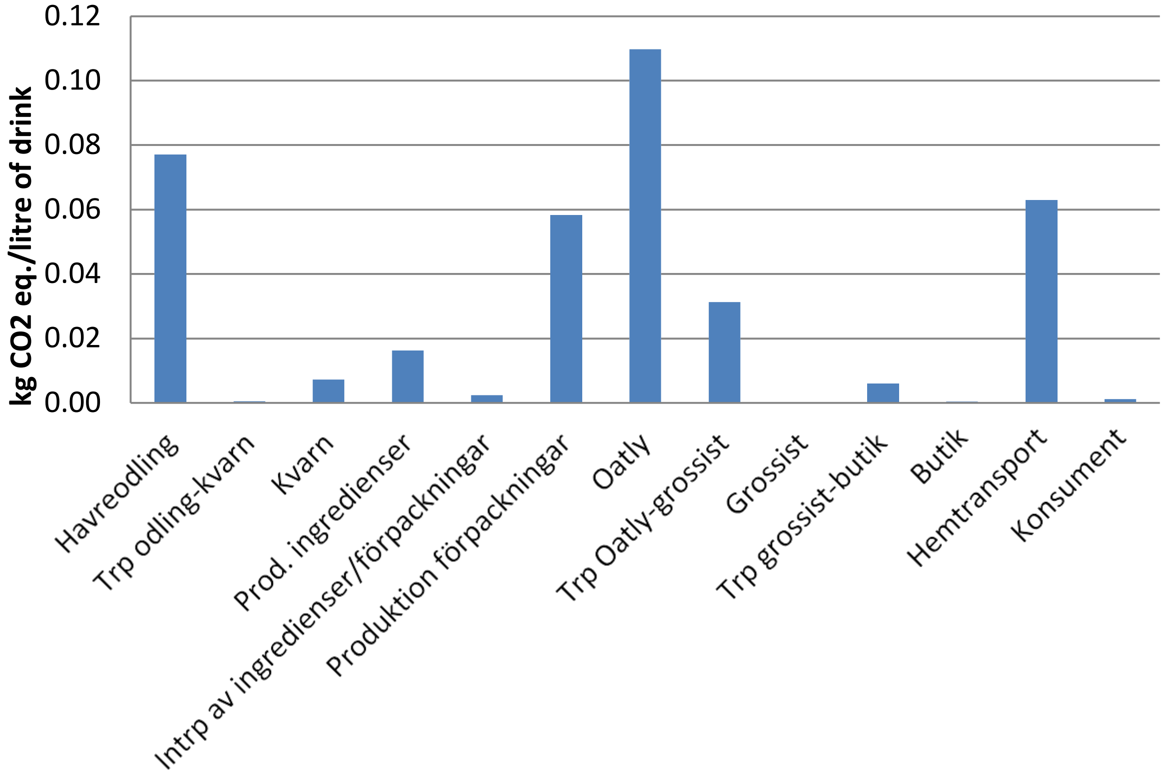


Figure 6: Distribution of the impact on climate at different stages of the chain for 1 litre of aseptic oat drink.

The three greatest contributors to the impact on climate of aseptic oat drink come from Oatly's production plant, oat cultivation and home transport.

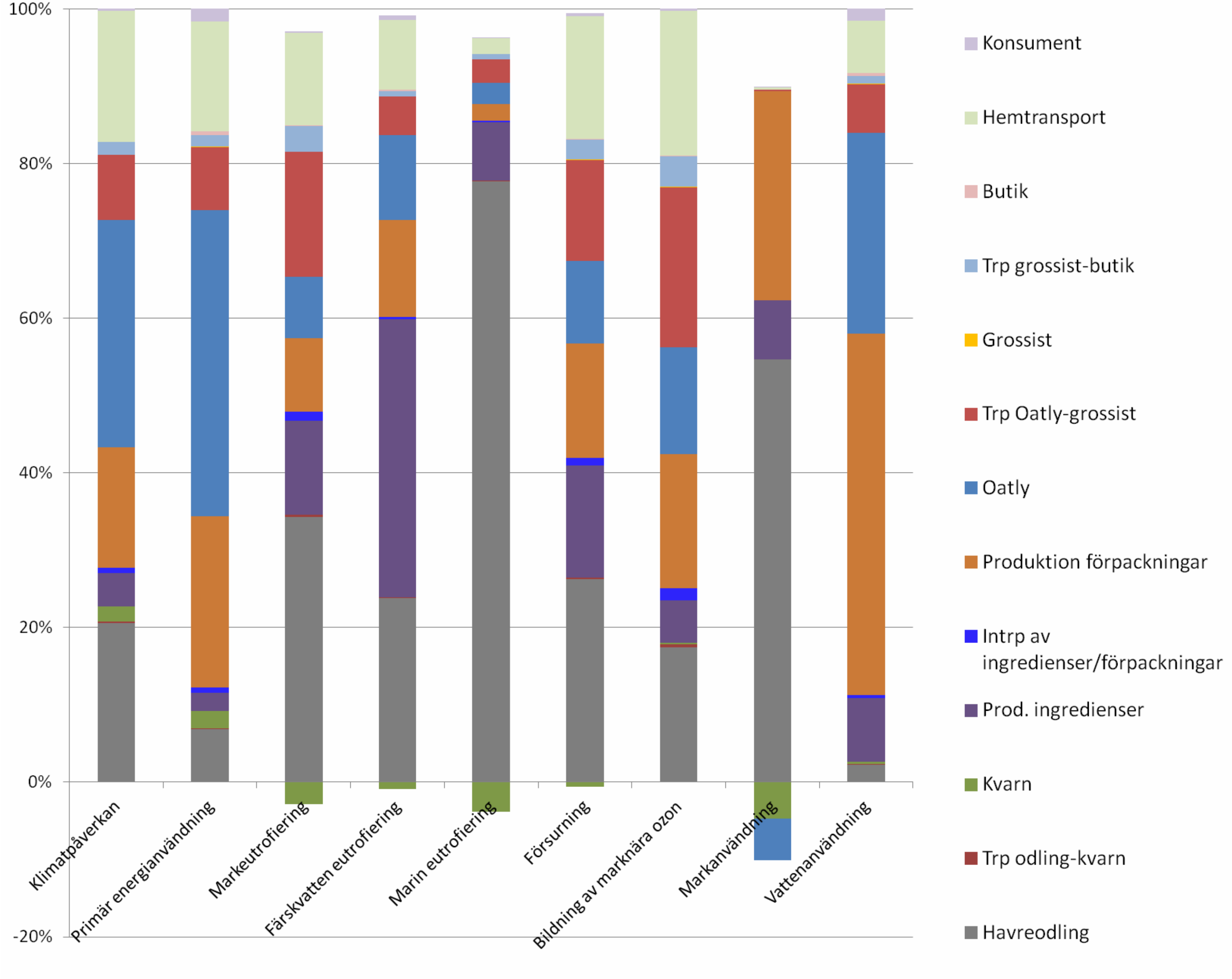


Figure 7: Breakdown of environmental impacts throughout the life cycle of one litre of aseptic oat drink

The negative portions of the bars in Figure 7 are explained by the system expansions which underlie the calculations from the mill and the Oatly plant. This relates to the residual bi-products animal feed and natural gas; the residual flows from the production process which now go to pig feed and biogas.

Figure 7 shows that oat cultivation gives a relatively large contribution to most of the environmental impacts, particularly the effects of eutrophication, land use and water consumption, but also more than 20
% of the total contribution goes to impact on climate and acidification.

With regards to contributions to eutrophication, it relates to the leaching of substances to water in connection with cultivation, while for soil eutrophication it relates to nitrous oxide (N_2O) and ammonia (NH_3) emissions. Nitrous oxide is also behind 2/3 of the climate contribution from oat cultivation, while ammonia is the greatest contributor to acidification, followed by sulphur dioxide and nitrogen oxide emissions.

Oatly's own production at the plant makes a significant contribution to the impact on climate category through primary energy consumption and water consumption. Regarding impact on climate, it relates exclusively to carbon emissions associated with the combustion of natural gas (about 85%) and electricity production.

The production of packaging is also responsible for a significant part of the environmental impact. Relatively speaking, the contribution from the packaging of the aseptic drink is greater than the contribution from the packaging of the fresh drink. The main reason for this is the aluminum layer in the packaging for the aseptic drink, which mainly contributes to impact on climate and energy consumption.

Transport also has a significant impact on several of the environmental impact categories. It's important to note that transport in the earlier stages of the life cycle has a lesser impact, while the transport to wholesale, as well as home transport, have the greatest impacts. Transport in the later stages of the chain is the least efficient, that's to say there's a relatively small amount of product transported per vehicle, which leads to a greater environmental impact per kg transported. Transport from Oatly to wholesale is one of the transports which Oatly could have more influence over. In this analysis, it has a major impact on acidification, tropospheric ozone formation and soil eutrophication, and therefore it may be worth analysing in more detail.

The results show that it's beneficial that the waste flows from the process are utilised as animal feed. The analysis (with its substantiated assumptions and data) shows that it's significantly more advantageous, from an environmental standpoint, that waste flows go to animal feed rather than to biogas production.

From a general viewpoint, the other parts of the life cycle have a minor impact on the environment.

Fresh oat drink

In the results, the substeps in the life cycle of the fresh oat drink have been divided as follows:

- Oat cultivation
- Transport farm to mill
- Mill
- Prod. ingredients
- Incoming shipments of ingredients/packaging
- Production of packaging
- Oat base, Oatly
- Transport Oatly to Germany
- Processing, Germany
- Transport Germany to Oatly
- Transport Oatly to wholesale
- Wholesale
- Transport wholesale to retail
- Retail
- Home transport
- Consumer

The total environmental impact of the fresh oat drink is presented in Table 25, while the distribution between the different phases of the life cycle is presented in Figure 8.

Table 25: Environmental impact of fresh oat drink, 1 litre

Environmental impact	**Results**	**Unit**
Impact on climate	0.49	kg CO2 eq.
Primary energy	9.18	MJ eq.
Soil eutrophication	0.0064	mol N eq.
Freshwater eutrophication	0.00019	kg P eq.
Marine eutrophication	0.0023	kg N eq.
Acidification	0.0019	mol H+ eq.
Tropospheric ozone	0.0017	kg NMVOC eq.
Land use	0.57	m^2
Water consumption	0.0080	m^3 of water eq.

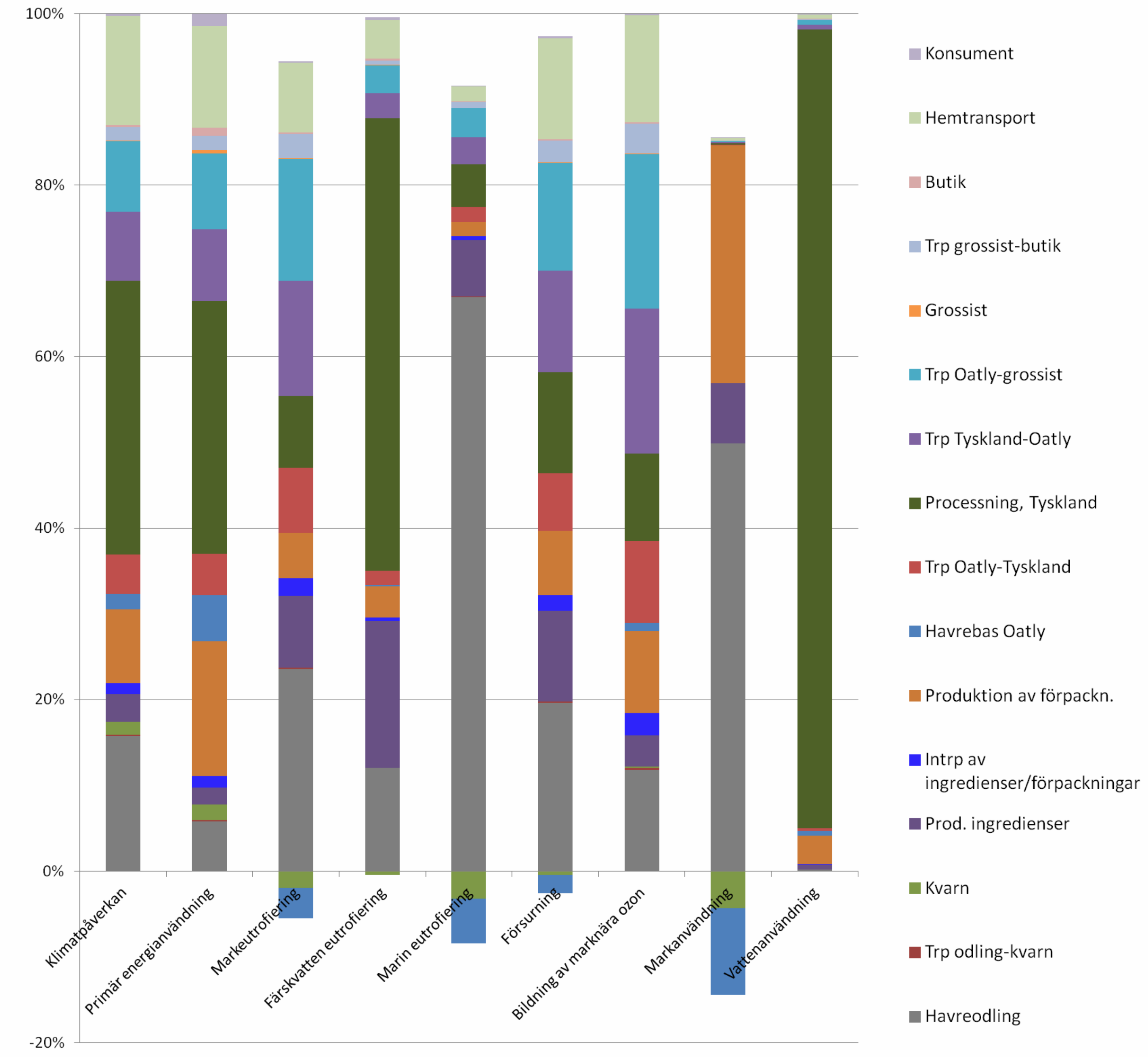


Figure 8: Distribution of environmental impacts throughout the life cycle of 1 litre of fresh oat drink

As an example of where in the chain environmental impact occurs, a breakdown of the chain in relation to impact on climate of fresh oat drink is shown in Figure 9. Regarding impact on climate of fresh oat drink, the three most dominant stages in the life cycle are: the processing in Germany, oat cultivation and home transport.

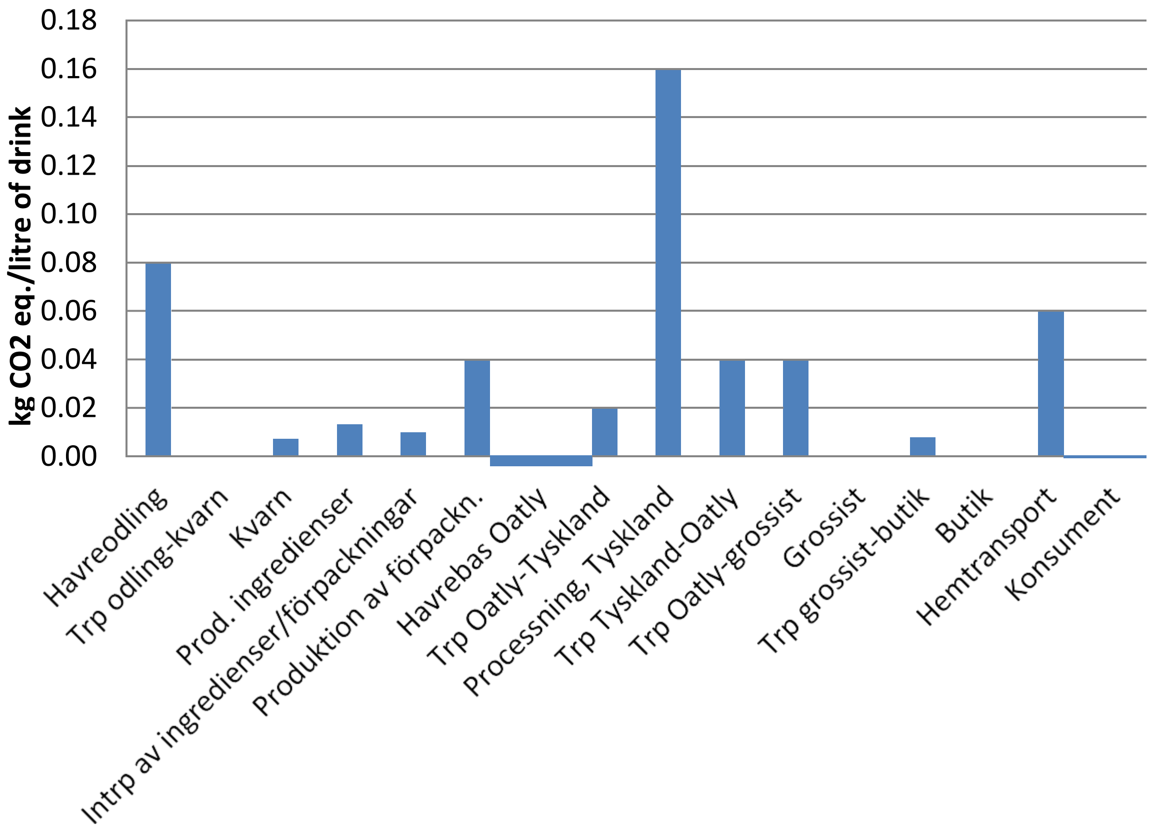


Figure 9: Distribution of the impact on climate at different stages of the chain for 1 litre of fresh oat drink.

The results for the fresh drink are slightly different from the aseptic drink. In general, the overall environmental impact of the fresh drink is slightly higher than the corresponding figure for the aseptic drink. This is explained by the fact that the production of the fresh drink requires more substeps, such as the industrial processing of the two plants, as well as additional transport steps. After production in Germany, the fresh drink also requires constant cold storage and additional transport. In the calculations for the fresh drink, there is a greater amount of product wastage when compared with the aseptic drink, which in turn affects the contribution from the production of raw materials.

A clear difference in the results between the aseptic and fresh oat drinks is that the plant in Germany accounts for a large share of the total environmental impact of the fresh drink. This is largely due to the fact that Germany's electricity production (which has a higher share of fossil fuels) has a much greater impact on most of the categories compared with Sweden's electricity production.

The total contribution from all the transport in the life cycle of the fresh drink is greater than the contribution from transport of the aseptic drink. This is partly due to two relatively long journeys (in comparison with the aseptic drink): the journeys from Landskrona to Schwerin and back, as well as the need for refrigerated transport, have a greater environmental impact due to the higher fuel consumption and the powering of the refrigerating units.

Oat cultivation also gives a relatively significant contribution to several of the environmental impact categories.

The contribution from packaging to the total environmental impact is less significant for the fresh oat drink than the aseptic drink. This is primarily due to the aluminum layer which the aseptic drink packaging demands, therefore having a greater environmental impact.

The contribution to climate from cold storage (wholesale, retail, consumer) is negligible, see Figure 9.

Milk

The breakdown of the life cycle stages are slightly different for milk compared with the oat drinks. This is partly because milk is based on earlier life cycle assessment data which is not broken down in the same way, and partly because milk is not distributed via wholesale, but goes directly from dairy to retail. The following life cycle stages are reported here for milk:

- Feed
- Farm
- Production of packaging
- Transport farm to dairy
- Dairy
- Transport dairy to retail
- Retail
- Home transport
- Consumer

The overall environmental impact of semi-skimmed milk is presented in Table 26, while the distribution between the different phases is presented in

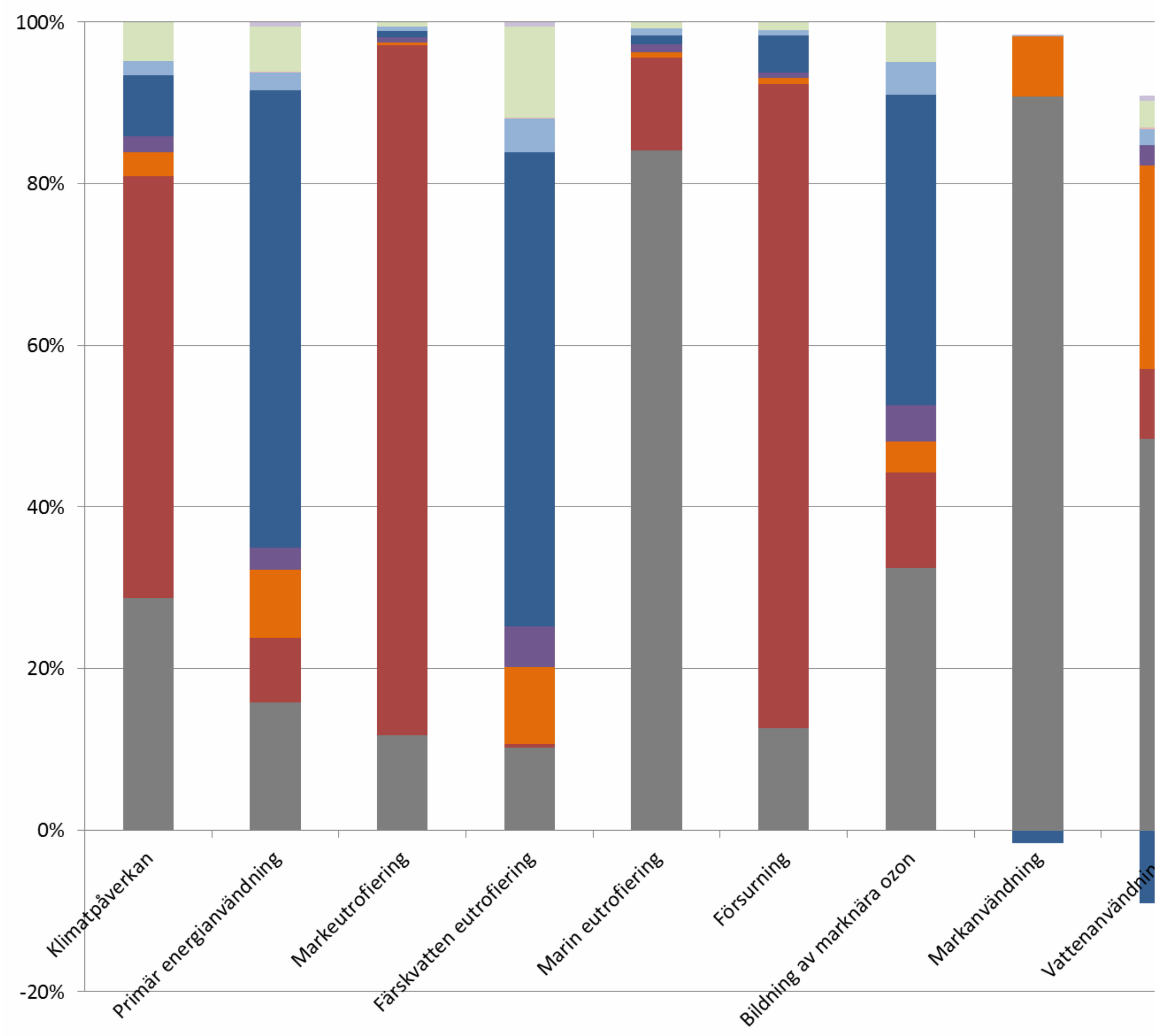


Figure 10.

Table 26: Environmental impact of semi-skimmed milk, 1 litre

Environmental impact	**Results**	**Unit**
Impact on climate	1.3	kg CO2 eq.
Primary energy consumption	19.6	MJ eq.
Soil eutrophication	0.103	mol N eq.
Freshwater eutrophication	0.00008	kg P eq.
Marine eutrophication	0.0061	kg N eq.
Acidification	0.0236	mol H+ eq.
Tropospheric ozone formation	0.0043	kg NMVOC eq.
Land use	2.9	m^2
Water consumption	0.0009	m^3 of water eq.

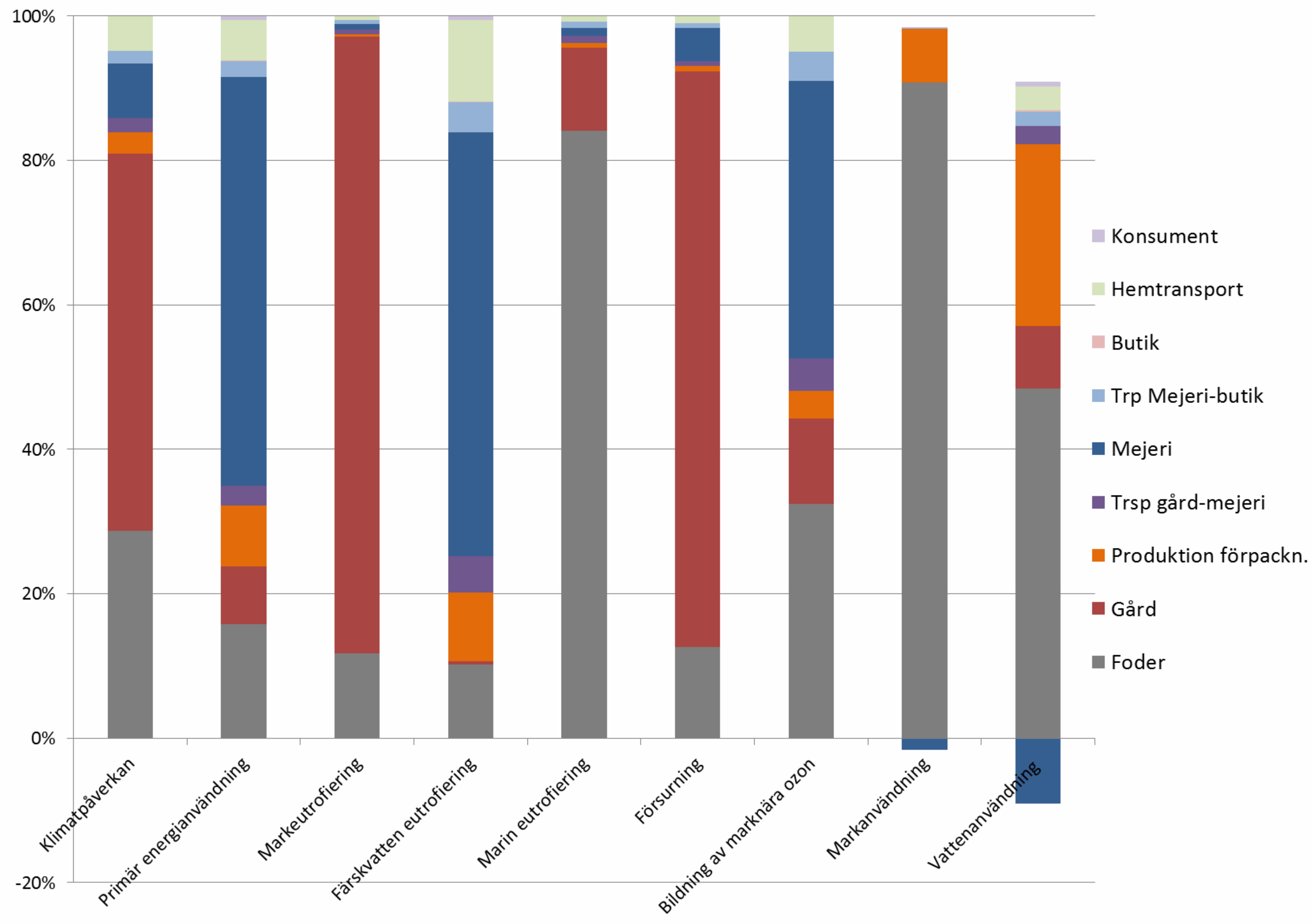


Figure 10: Distribution of environmental impacts throughout the life cycle of 1 litre of semi-skimmed milk

As an example of where in the chain environmental impact occurs, a breakdown of the chain in relation to impact on climate of semi-skimmed milk is shown below, Figure 11. In the life cycle for milk, there are two very dominating stages regarding impact on climate: feed production and the milk production on the farm.

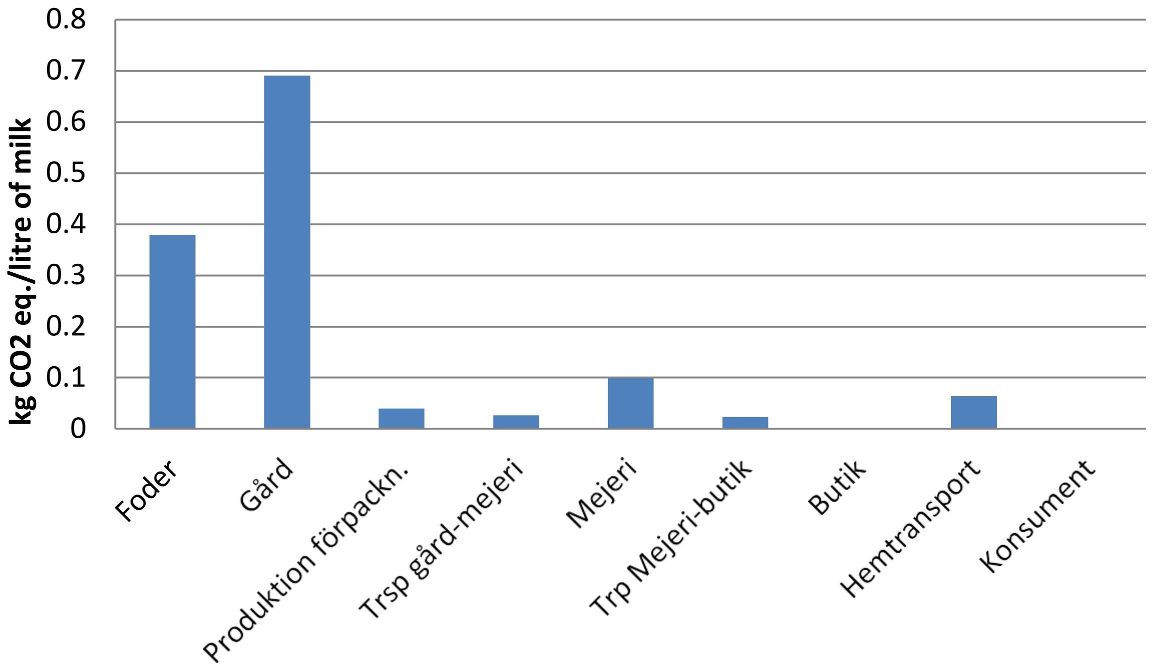


Figure 11. Distribution of the impact on climate at different stages of the chain for 1 litre of semi-skimmed milk.

Milk has a significantly higher impact on the majority of the environmental impact categories than the aseptic and fresh oat drinks. Like many animal products, the majority of the environmental impacts occur early in the life cycle of milk: in the primary production of milk at the farm and in feed production. Emissions of ammonia, nitrous oxide and the leaching of substances associated with feed production, as well as biogenic emissions of methane from animals and manure, make significant contributions.

Even the dairy contributes to the environmental impact, especially in the categories of primary energy consumption, freshwater eutrophication and tropospheric ozone formation.

Home transport at consumer level has the greatest environmental impact in the life cycle of milk. To some extent, the production of packaging has an affect in the categories of primary energy consumption and freshwater eutrophication, but the impact is fairly small in the other catergories.

Results - Comparison of the drinks

The environmental impact of all the drinks in relation to each other is summarised in Table 27. In most of the environmental impact categories, milk has a significantly higher impact than either of the Oatly oat drinks. This can be explained by the fact that milk production is a more complex and environmentally sensitive process, including feed production, the management of manure from the animals, and the methane emissions associated with animal rumination.

Table 27: Summary of the results comparison between aseptic oat drink, fresh oat drink and semi-skimmed milk

Environmental Impact	Aseptic oat drink	Fresh oat drink	Milk	Unit
Impact on climate	0.4	0.5	1.3	kg CO2 eq.
Primary energy	7.7	9.2	19.6	MJ eq.
Soil eutrophication	0.005	0.006	0.103	mol N eq.
Freshwater eutrophication	0.00010	0.00019	0.00008	kg P eq.
Marine eutrophication	0.002	0.002	0.006	kg N eq.
Acidification	0.002	0.002	0.024	mol H+ eq.
Tropospheric ozone	0.001	0.002	0.004	kg NMVOC eq.
Land use	0.6	0.6	2.9	m^2
Water consumption	0.0005	0.008	0.0009	m^3 of water eq.

Pink indicates the maximum environmental impact of the drinks within the same impact category.

The results also show that the fresh oat drink has a slightly higher environmental impact than the aseptic drink. This is because the production of the fresh drink takes place partially in Germany, with a less efficient use of electricity, as well as longer transport times (which, in addition, require the payment of refrigeration levies). The aseptic drink has a greater contribution from the packaging, but, on the whole, this does not make a great difference.

Of all three drinks, the fresh oat drink has the greatest impact in the categories of freshwater eutrophication and water consumption. The fresh oat drink's main contribution from eutrophication of freshwater comes from the German electricity production, which causes phosphate emissions to water. When it comes to water consumption, the higher value for the fresh drink is caused by the difference in the weighting factors in the characterisation method of using water of German origin compared to Swedish. This method indicates that using water in Germany, as oppose to Sweden, has an effect that is about 300 times more impacting. Research is still ongoing to determine which method is best and most representative for the assessment of water consumption. In the ILCD method used (which was recommended to us by the EU), these weighting factors are included. However, the recommendation was to use the method for water consumption with some caution. Both parameters regarding the usage of German water and electricity have been analysed in a sensitivity analysis. See Table 29 below.

Impact on climate is the environmental effect which is given most focus in relation to the overall environmental impact of food production. In Figure 12, the drinks' total impact on climate, calculated per functional unit, is show. For corresponding figures in the other environmental impact categories, see Appendix 3.

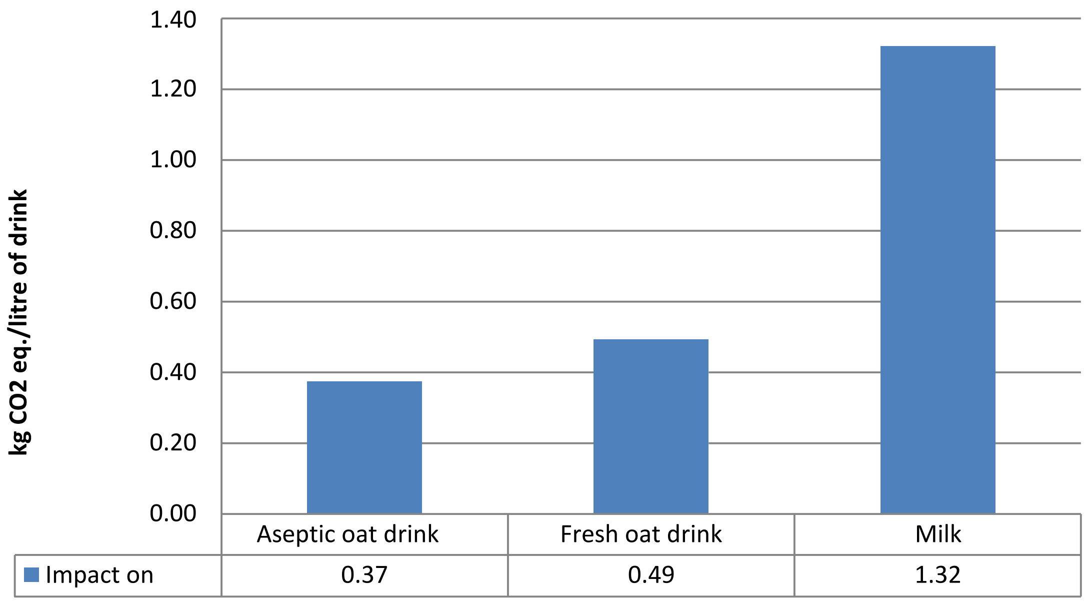


Figure 12: **Comparison of the impact on climate of aseptic oat drink, fresh oat drink and semi-skimmed milk**

Use of pesticides

No calculation of ecotoxicity has been made in this project. However, a comparison of pesticide use has been made between the aseptic oat drink, fresh oat drink and milk. The comparison showed that for the preparation of 1 litre of oat drink (both fresh and aseptic), 10-15% is used of the total amount of active substances in pesticides used to produce 1 litre of milk. This calculation is based on data on pesticide use by the oat farmers which deliver to Oatly, as well as feed use in connection with Swedish milk production according to Cederberg et al (2009) and pesticide use in feed production according to the SIK LCA feed database (www.sikfoder.se). Such a difference in pesticide use does not necessarily mean corresponding differences in ecotoxicological effects from the production of the various drinks. However, the knowledge we have about which pesticides are used in which cases allows us to conclude that oat drink production has a significantly lower ecotoxic effect from pesticide use than the production of conventional milk. The main explanation for the big difference in pesticide use is the difference in land use. The arable land used for oat cultivation to produce 1 litre of oat drink is about 15-20% of the arable land used for feed production in order to produce 1 litre of milk.

Impact on climate from the transportation of the oat drink.

The total contribution from transport makes up about 1/3 of the total impact on climate for both oat drinks; 29% for the aseptic drink and 38% for the fresh drink. The transport contribution is higher from the fresh drink because distances are longer (to Germany and back) and the product has to be transported in a refrigerated unit. Refrigerated transport has a 30% higher contribution than non-refrigerated transport. If the aseptic drink would be transported in refrigerated units after production, the overall contribution from transport for the aseptic drink would increase by about 13%.

The transport which has the greatest impact on climate is home transport, in other words the private transport made by the consumer to their home, shown in Figure 13 and Figure 14. It is this transport in the chain which is least efficient and often the transport which has the greatest contribution of all transport in the chain for a food product.

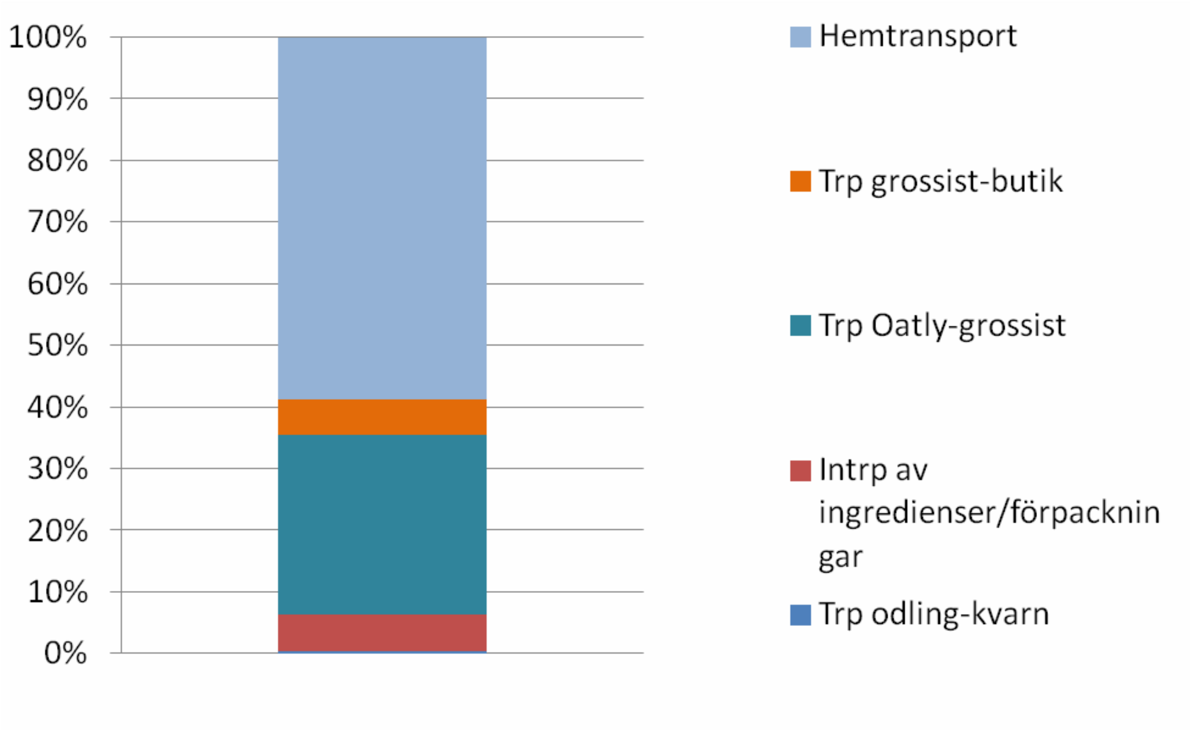


Figure 13: Distribution of the climate contribution from transport in the aseptic oat drink chain

Transport from Oatly to wholesale is the transport step which Oatly should optimise in order to reduce climate contribution from the transport of the aseptic drink.

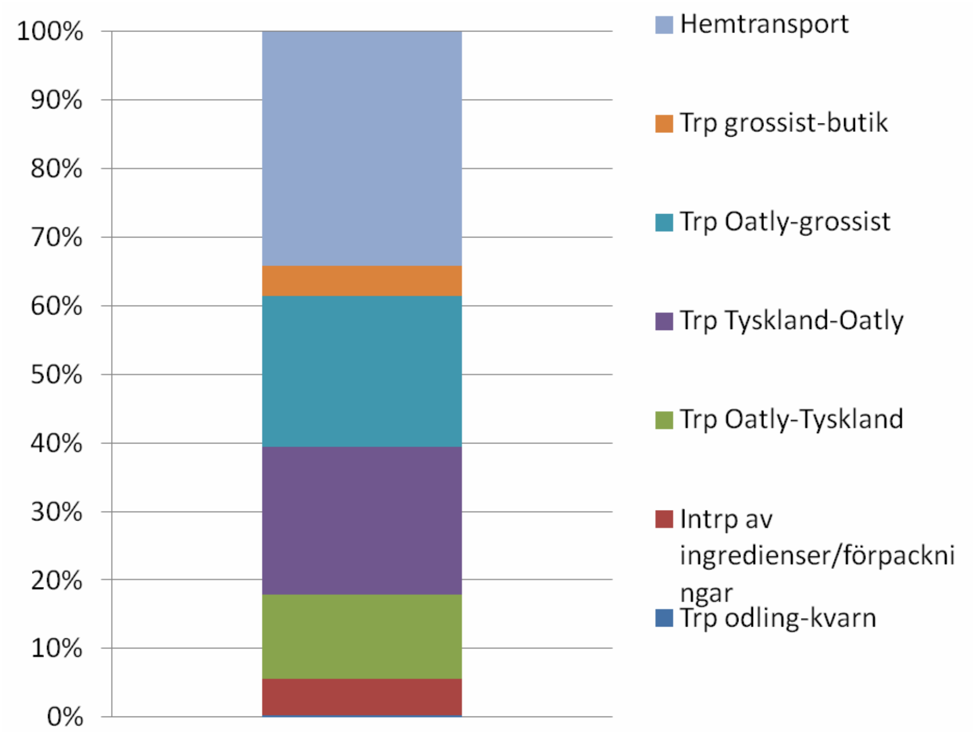


Figure 14: Distribution of the climate contribution from transport in the fresh oat drink chain

Transport from Germany and from Oatly to wholesale are the transport steps which Oatly should optimise in order to reduce climate contribution from the transport of the fresh drink.

DISCUSSION OF RESULTS AND SENSITIVITY ANALYSES

Sensitivity analysis oat cultivation, comparison with other cultivation data for oats

In connection with the inventory for oat cultivation, with the delivery of oats to Oatly, specific input values were not obtained for all the parameters. Therefore, these are modelled by SIK's agronomist Magdalena Wallman. However, Oatly wants to know how its cultivation of oats stands in relation to Swedish oat farming in general. The comparison shows that the oats cultivated in connection with Oatly production have greater fertilisation, but also that the yield is higher. This is reflected in the following way if one compares a kg of oats (at farm level), Table 28.

Table 28: Comparison of the environmental impacts of 1 kg of oats (N.B. not drink) cultivated on an average Swedish oat farm and that cultivated on Oatly's farm.

	Average Swedish	Oatly's oats	Unit
Impact on climate	0.42	0.39	kg CO2 eq.
Primary energy consumption	2.88	2.73	MJ eq.
Soil eutrophication	0.0148	0.0084	mol N eq.
Freshwater eutrophication	0.00007	0.00024	kg P eq.
Marine eutrophication	0.0088	0.0089	kg N eq.
Acidification	0.0035	0.0022	mol H+ eq.
Tropospheric ozone formation	0.0012	0.0011	kg NMVOC eq.
Land use	2.63	1.88	m2
Water consumption	0.00013	0.00020	m3 water eq.

The results show that Oatly's oats are slightly more advantageous for the majority of environmental effects, however, one should be aware that there are inherent uncertainties in the crop results. If one looks at how it affects the overall result of the finished product at consumer level, the differences are greatest for those environmental impacts where there's a difference in oat cultivation system and where the cultivation has a central role in the oat drink's total environmental impact, such as land use and water consumption.

Sensitivity Analysis: What would happen if the fresh oat drink would also be produced in Sweden?

The results show that the fresh oat drink has the greatest environmental impact of the three drinks with regards to water consumption and freshwater eutrophication. The reason for this is that the fresh oat drink is processed in Germany and, as a result, we had to use Germany's average value for electricity and water consumption. Germany's electricity production differs to that of Sweden's in the use of more fossil fuels as primary energy sources. The characterisation method for
water consumption takes into account the land in which the water is consumed. One m^3 of water in Sweden has a low weighting factor of 0.00468 m^3 of water eq., while 1 m^3 of water in Germany has a relatively high weighting factor of 1.52 m^3 of water eq. Both these parameters have an impact on the results.

To clarify this further, a simplified sensitivity analysis has been carried out where 1 litre of oat drink without packaging (steps after the factory are not included) from each of the production conditions, German and Swedish, is compared. The only thing we changed is we swapped the electricity and water consumption at the German plant for the Swedish equivalents. Everything else remains unchanged, e.g. the transport of oat base to Germany is still included. One can clearly see that if the production of the fresh oat drink took place in Sweden and the production parameters would be the same as in Germany, there would be no significant differences between the two oat drinks, Table 29.

Table 29. Environmental impact of 1 litre of oat drink (without packaging): the fresh drink under German production conditions, the fresh drink under Swedish conditions and the aseptic drink.

Environmental Impact Category	Fresh oat drink*, German conditions	Fresh oat drink Swedish conditions	Aseptic oat drink*	Unit
Impact on climate	0.328	0.261	0.260	kg CO2 eq.
Freshwater eutrophication	$16.5*10^{-5}$	$7.28*10^{-5}$	$7.72*10^{-5}$	kg P eq.
Water consumption	0.00763	0.000439	0.000439	m^3 of water

** These constitute the actual products in the analysis*

Sensitivity analysis for milk: What happens if we include the contribution from land use change in connection with the cultivation of soya which goes to cattle feed?

Most of the soya used in feed for Swedish cattle is imported from Brazil. There is an ongoing expansion of soya bean production in Brazil through the cultivation of new land, including rainforest land. In connection with deforestation and the clearing/cultivation of new land, there are emissions of greenhouse gases. There is currently no internationally accepted calculation method to calculate how great this effect is and how significant the contribution from soya cultivation is. In this case, the change implemented is the transformation of grassland, scrubland and woodland into farmland, which would increase soya flour's carbon footprint by 1.75 kg CO_2eq. per kg (calculated using economic allocation between soya flour and soybean oil). The assumed level is based on the scenario II for Brazil, according to Leip et al (2010). Converted to climate contribution per litre of milk, it becomes 60 g CO_2 eq. This means that the contribution from one litre of milk increased from 1.32 to 1.38 kg CO_2 eq.

The environmental impact of packaging

In 2009, Tetra Pak allowed IVL (Swedish Environmental Research Institute) to carry out a comparative LCA of a variety of packaging including many of Tetra Pak's drinks packaging, among others Tetra Brik aseptic packaging with cap which is used for Oatly's aseptic oat drink. We have chosen not to use the already characterised result for Oatly's packaging, but instead we added specific information about the packaging materials to our analysis tool, thus making our own characterisation. In this way, we can compare the oat drink and milk packaging in a fairer manner.

When comparing the climate contribution from a Tetra Bric aseptic packaging (with cap) as given in the characterised results in the IVL report with our own results, we can see that the contribution from this packaging is slightly lower in our report. Above all, it is due to the fact that the system boundaries in the IVL report and our report are different. Included in our report's results for packaging is the manufacture of all the ingoing raw materials, the contribution from the manufacture of the finished packaging and the emissions resulting from the incineration of the packaging (the percentage of packaging which is incinerated). When the three are compared, it's the aseptic packaging which has the greatest environmental impact. This is due to the aluminum film which is used in the aseptic packaging, not present in the other two types of packaging.

CONCLUSIONS

- The study shows that Oatly oat drinks have a lesser environmental impact than semi-skimmed milk.

- With production organised as it is today (the fresh drink produced in Germany), the life cycle assessment shows that, from an environmental perspective, the aseptic drink is preferable to the fresh drink. If the production of the fresh drink would take place in Sweden instead (with the same processing parameters but with Swedish conditions), the results would have been different and the difference between the aseptic and fresh drinks would have been be small.

- The plant in Landskrona is a hotspot for the production of the aseptic drink with regards to impact on climate, energy and water consumption.

- The plant in Germany is a hotspot for the production of the fresh drink with regards to impact on climate, energy and water consumption, and freshwater eutrophication.

- Climate contribution from transport accounts for about a third of the total climate contribution from the oat drinks, with a slightly greater contribution from the fresh product. This is partly because the fresh drink has longer transport distances and that transportation after factory is refrigerated.

- Home transport is the transport that has the greatest environmental impact.

- Transport from Oatly to wholesale gives a relatively large contribution to the environmental impact and should be analysed in more detail.

- Contribution to climate from cold storage of the fresh oat drink (after production) is marginal.

- There is potential for improvement in the production of both the aseptic and fresh oat drinks.

- The environmental impact of the aseptic drink packaging is greater than from the fresh drink packaging.

REFERENCES

Adolfsson, R. 2005. A review of Swedish crop residue statistics used in the greenhouse gas inventory. SMED Report No. 65 2005. SMED - Swedish Environmental Emissions Data.

Arla Foods (2004). Our responsibility 2003, Arla Foods Stockholm, The Biosubstrate

Handbook, http://www.biogasnordic.se/dokument/SGC200.pdf

Berglund Maria, SIK, personal message, 2012

Bååth Jacobsson, Susanne, VÄXA, personal message, 2013

Cederberg C, Sonesson U, Henriksson M, Sund V and Davis J. 2009. Greenhouse gas emissions from Swedish production of meat, milk and eggs 1990 and 2005. SIK Report No. 793. September 2009. Gothenburg

Ecoinvent Centre (2007): ecoinvent data v2.0. Ecoinvent reports No. 1-25. Swiss Centre for Life Cycle Inventories. Duebendorf. Switzerland.

EMEP/EEA air pollutant emission inventory guidebook, part B, 4.D. Agricultural Soils — 2009

European Commission, Joint Research Centre, Institute for Environment and Sustainability. Characterisation factors of the ILCD Recommended Life Cycle Impact Assessment methods. Database and Supporting Information. First edition. February 2012. EUR 25167. Luxemburg. Publications Office of the European Union; 2012.

Eriksson Mattias, Strid Ingrid (2011) Food wastage at retail level - a study of wastage at six grocery stores. SLU report 035. Department of Energy and Technology at SLU (Swedish University of Agricultural Sciences)

Forster P V et al. 2007. Changes in Atmospheric Constituents and in Radiative Forcing. In: Climate Change 2007: The Physical Science Basis. *Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Frischknecht R, Jungbluth N, et al. 2003. Implementation of Life Cycle Impact Assessment Methods. Final report ecoinvent 2000, Swiss Centre for LCI. Duebendorf, CH, www.ecoinvent.ch (LCA methodology to calculate primary energy consumption (Cumulative Energy Demand, CED), based on a method published by Ecoinvent, version 1.01, and further developed by PRé Consultants. SimaPro 7.1)

Frischknecht R, Steiner R, Jungbluth N, (2009). – Swiss ecoscarcity 06, The Ecological Scarcity Method – Eco-Factors 2006: A method for impact assessment in LCA. Bern, Switzerland, Wirtschaften.

GRYAAB Annual Report 2012, http://www.gryaab.se/arsredovisning2012/#/30

Guinée J, Goree M, Heijungs R, Huppes H, Kleijn R, de Koning A, van Oers L, Wegener Sleeswijk A, Suh S, Udo de Haes H, de Bruijn H, van Duin R and Huijbregts M. (2002), Handbook on Life Cycle Assessment, Operational Guide to the ISO Standards, Dordrecht:Kluwer Academic Publishers. (LCA method (CML, 2001) which was developed at the Institute of Environmental Sciences (CML) at Leiden University). SimaPro 7.1. Updated 2008.

ILCD Handbook: Recommendations for Life Cycle Impact Assessment, JRC European Comission, 2010

IPCC. 2006. IPCC Guidelines for National Greenhouse Gas Inventories – Volume 4, Agriculture, Forestry and Other Land Use. Intergovernmental Panel on Climate Change (IPCC).

IPCC, 2007. Climate Change 2007: Intergovernmental Panel for Climate Change (IPCC) Fourth Assessment Report. The Physical Science Basis http://www.ipcc.ch/ipccreports/ar4-wg1.htm

ISO 2006a: Environmental management – Life cycle assessment – Principles and framework. ISO 14040:2006(E). International Organization Standardization. Geneva. Switzerland

ISO 2006b: Environmental management – Life cycle assessment – Requirements and guidelines. ISO 14044:2006(E). International Organization for Standardization. Geneva. Switzerland.

Climate Labelling. Food transportation and impact on climate, basis for climate certification, Report 2010, 1.
http://www.klimatmarkningen.se/wp-content/uploads/2009/11/2010_1_transporter.pdf

Leip, A., Weiss, F., Wassenaar, T., Perez, I., Fellmann, T., Loudjani, P. et al. 2010. Evaluation of the livestock sector's contribution to the EU greenhouse gas emissions (GGELS). Final report. Joint Research Centre (JRC), European Comission, Brussels, Belgium.

Environmental Protection Agency Sweden, Report 5823, Leaching of nutrients from Swedish farmland, calculations of nitrogen and phosphorus leaching in 1995 and 2005, 2008

Environmental Protection Agency Sweden, 2012
http://www.naturvardsverket.se/Start/Produkter-och-avfall/Ozonnedbrytande-amnen/Koldmedieforteckning/

Nilsson, K and Lindberg U, Impact on climate from cold storage in the chain, from agri-food producer to consumer, SLV, Report 19, 2011.

NTM (Network for Transport Measures), NTMcalc 3, Professional, 2012

ReCiPe v 1.05. www.lcia-ReCiPe.net

RVU Sweden 2011- The Swedish National Travel Survey

SIK Food Database, the SIK environmental database, 2012, contact person: Britta Florén at SIK

Van Zelm R., Huijbregts M.A.J, Harbers J.V., Wintersen A.,Struijs J.,Posthuma L., Van De Meent D. (2007) Uncertainty in msPAF-based ecotoxicological freshwater effect factors for chemicals with a non-specific mode of action in life cycle assessment. Integrated Environmental Assessment and Management. 3(2): 203-210.

Environmental Reports (gleaned from regulatory authorities in each respective municipality):

Environmental Report, Arla Foods Dairy,

Gothenburg; the 2011 Environmental Report, Arla

Foods Jönköping; the 2011 Environmental Report

Arla Foods Dairy, Linköping

Annual Environmental Report 2011 for the operations at Arla Foods Stockholm Dairy in Kallhäll, Järfälla Municipality, Stockholm County

Personal communication:

Andreas Holmström, Traffic Analysis, 2013

Carin Classon, Hushållningssällskapet Halland

(Rural Economy and Agricultural Society, Halland),

2012 Johan Samuelsson, Varaslättens Lagerhus

(Varaslätten's Warehouse), 2013.

Linda Eriksson, Development Engineer, Oatly AB,

2013. Maria Berglund, SIK, 2012.

Susanne Bååth Jacobsson, VÄXA, 2013

APPENDIX 1

Breakdown of energy, production of aseptic drink

	Total for aseptic, enriched drink in 2012 based on 4,756,374 kg		
Energy consumption specified at each production process step (units specified as MJ/kWh/t/m3 or as a percentage of the total)	Electricity in kW	Natural gas kW	kV, refrigeration
1. Oat silos	2,265	0	0
2. The heating of water for milling, steaming, as well as warm water surplus incl. CIP	906.0	100,563.396	0
3. Milling: 2 colloid mills at 75 kW each, 1 plate mill at 65 kW and 1 pump at 2.2 kW incl. CIP	79,726	2,265	0
4. Enzymation 1 incl. CIP	2,265	2,265	0
5. VB 1 incl. CIP	7,248	61,154	4,530
6. Enzymation 2 incl. CIP	4,077	2,265	0
7. VB 2 incl. CIP	7,248	61,154	4,530
8. Separation, decanting incl. CIP	36,692	4,530	0
9. Ingredients, formulation incl. CIP	8,607	2,265	0
10. Final cooling incl. CIP	49,829	2,265	9,060
11. Silo storage incl. CIP	1,812	2,265	0
12. UHT	223,323	1,233,033	6,795
13. Sterile tank	6,795	55,265	0
14. Filling, TBA 21	72,478	11,325	0
15. Retrofitting	13,590	0	0
16. Palletising and wrapping	9,060	0	0
17. Goods warehouse	79,473		
18. Maintenance and equipment (compressor, etc.)	8,154	2,718	0
19. Laboratory and office	30,360		
Total:	**643,907**	**1,543,331**	**24,914**

Breakdown of energy, production of the oat base

	Total for oat base (14% DM) to Germany in 2012 based on 1,350,000 kg		
Energy consumption specified at each production process step (units specified as MJ/kWh/t/m3 or as a percentage of the total)	Electricity in kW	Natural gas kW	*kV, refrigeration m3*
1. Oat silos	643	0	*0*
2. The heating of water for milling, steaming, as well as warm water surplus incl. CIP	257.0	28,543	*0*
3. Milling: 2 colloid mills at 75 kW each, 1 plate mill at 65 kW and 1 pump at 2.2 kW incl. CIP	22,629	643	*0*
4. Enzymation 1 incl. CIP	643	643	*0*
5. VB 1 incl. CIP	2,058	17,357	*1,286*
6. Enzymation 2 incl. CIP	1,157	643	*0*
7. VB 2 incl. CIP	2,058	17,357	*1,286*
8. Separation, decanting incl. CIP	10,415	1,286	*0*
9. Ingredients, formulation incl. CIP	2,443	643	*0*
10. Final cooling incl. CIP	14,143	643	*2,571*
11. Silo storage incl. CIP	514	643	*0*
12. UHT			
13. Sterile tank			
14. Filling, TBA 21			
15. Retrofitting			
16. Palletising and wrapping			
17. Goods warehouse, Germany			
19. Laboratory and office, Germany			
17. Goods warehouse, Oatly (included in data for Germany, based on 1,690 tonnes)	57,336		
18. Maintenance and equipment (compressor, etc.)	2,314	771	*0*
19. Laboratory and office (included in data for Germany, based on 1,690 tonnes)	11,160		
Total:	127,767	69,173	5,143
Total excl. entries 17 and 19	59,272		

Breakdown of energy, production of fresh drink at the plant in Germany

	Steps marked in blue take place at the plant in Germany, but based on Oatly's values on 1,690 tonnes of		
Energy consumption specified at each production process step (units specified as MJ/kWh/t/m3 or as a percentage of the total)	Electricity in kW	Natural gas kW	*kV,*
1. Oat silos			
2. The heating of water for milling, steaming, as well as warm water surplus incl. CIP			
3. Milling: 2 colloid mills at 75 kW each, 1 plate mill at 65 kW and 1 pump at 2.2 kW incl. CIP			
4. Enzymation 1 incl. CIP			
5. VB 1 incl. CIP			
6. Enzymation 2 incl. CIP			
7. VB 2 incl. CIP			
8. Separation, decanting incl. CIP			
9. Ingredients, formulation incl. CIP			
10. Final cooling incl. CIP			
11. Silo storage incl. CIP			
12. UHT	77,146	425,943	2,347
13. Sterile tank	2,347	19,091	0
14. Filling, TBA 21	25,037	3,912	0
15. Retrofitting	4,694	0	0
16. Palletising and wrapping	3,130	0	0
17. Goods warehouse, Germany	see processing, Germany		
19. Laboratory and office, Germany	see processing, Germany		
17. Goods warehouse, Oatly (included in data for Germany, based on 1,690 tonnes)	112,354	448,946	2,347
18. Maintenance and equipment (compressor, etc.)			
19. Laboratory and office (included in data for Germany, based on 1,690 tonnes)			

From sheet processing, Germany	12,675	(45/6*1690)
From oat base processing entries 17 and 19, based on 1,690 tonnes	68,496	57,336+11,160
Total:	193,525	

APPENDIX 2

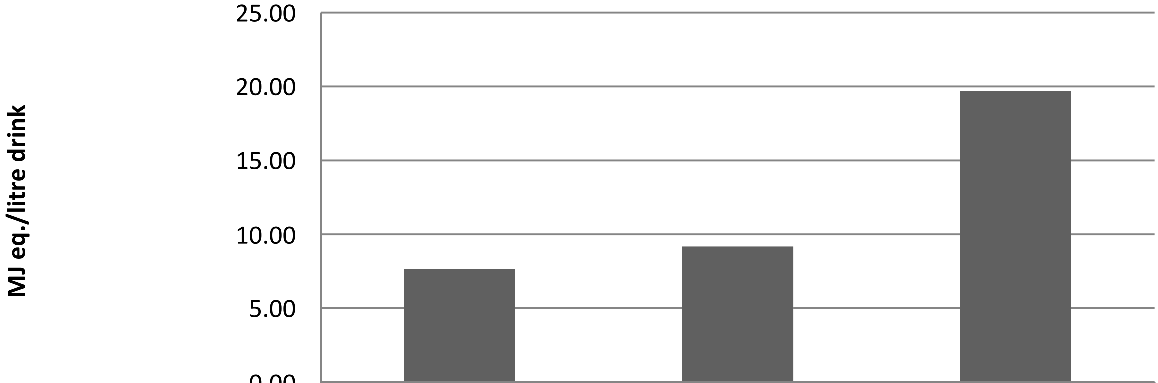
Nutritional and energy content, oat fibre slurry

Oat fibre slurry 2011-10-12

Analysis	Results	Unit	Method/ref
Crude protein N*6.25 (Kjelldahl)	285	g/kg DM	152/2009 EU mode
Crude fat acc. to the EC method	140	g/kg DM	152/2009 EU mode
Ash content	73	g/kg DM	152/2009 EU mode
Dry matter	22.1	%	152/2009 EEC mode
Crude fibre	81	g/kg DM	ASN Tecator 3428
Neutral detergent fibre (NDF)	443	g/kg DM	Tecator 304 LidNär.0A.21
Metabolisable energy for pigs	15.8	MJ/kg DM	
Calcium Ca	0.06	%	NMKL No. 139 1991
Phosphorus P	0.25	%	NMKL No. 139 1991
Magnesium Mg	0.10	%	NMKL No. 139 1991
Sodium Na	<0.02	%	NMKL No. 139 1991
Potassium K	0.10	%	NMKL No. 139 1991
Cysteine	8.4	g/kg DM	SS EN-ISO 13903:2005
Methionine	5.2	g/kg DM	SS EN-ISO 13903:2005
Threonine	11.2	g/kg DM	SS EN-ISO 13903:2005
Lysine	16.3	g/kg DM	SS EN-ISO 13903:2005

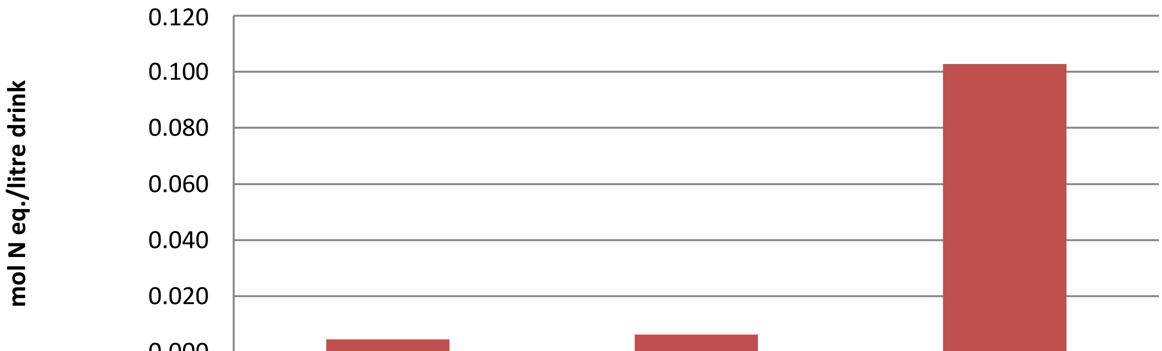
The total environmental impact from one functional unit of the different drinks, broken down by environmental impact.

Primary energy consumption



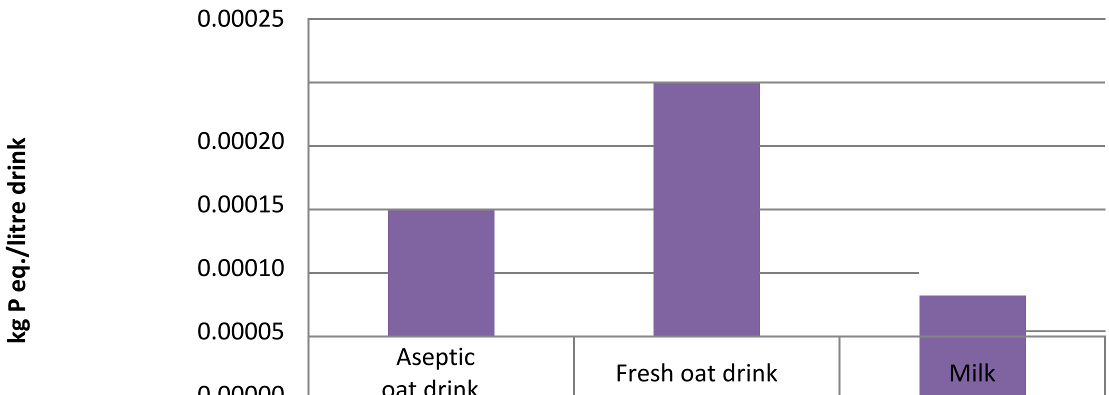
	Aseptic oat drink	Fresh oat drink	Milk
Primary energy consumption	7.66	9.18	19.7

Soil eutrophication

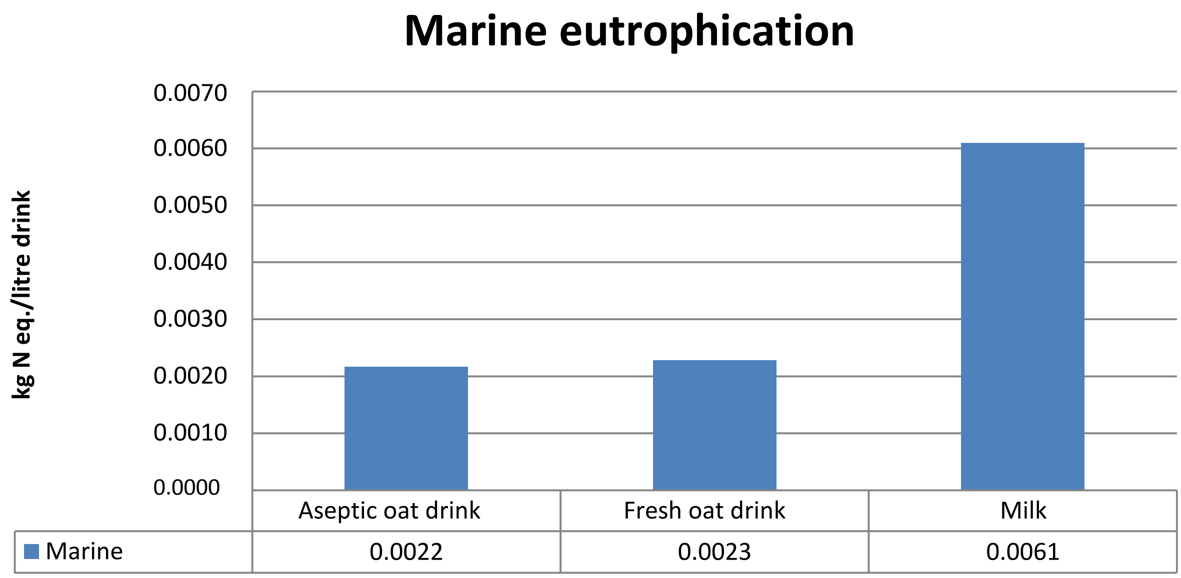


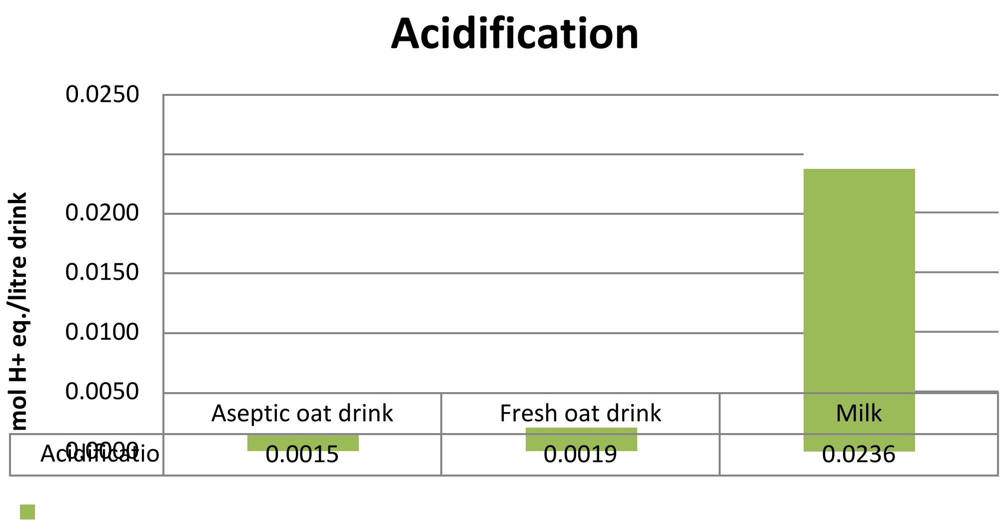
	Aseptic oat drink	Fresh oat drink	Milk
Soil eutrophication	0.005	0.006	0.103

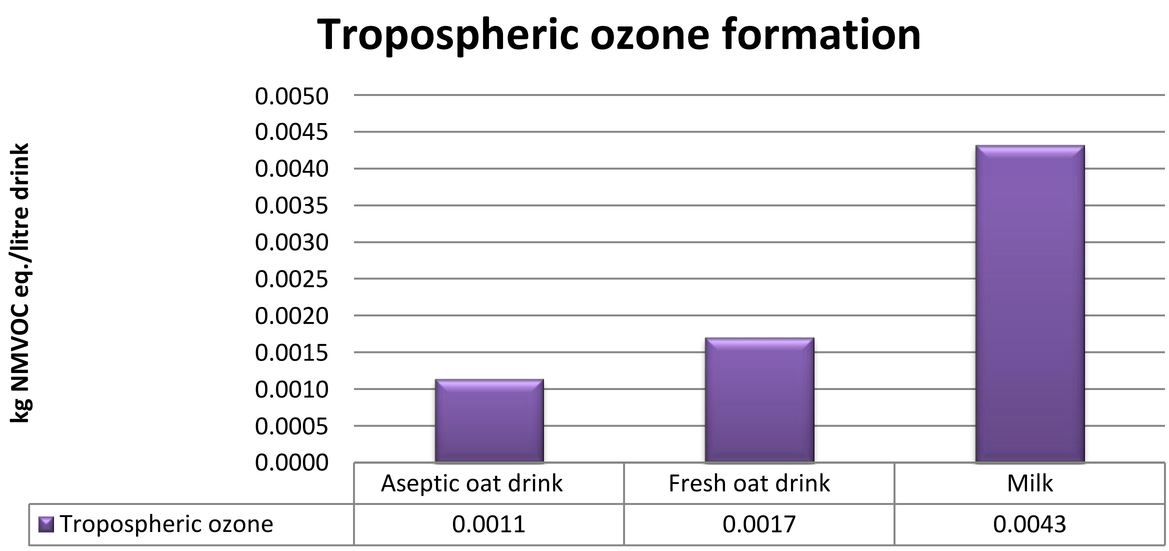
Freshwater eutrophication

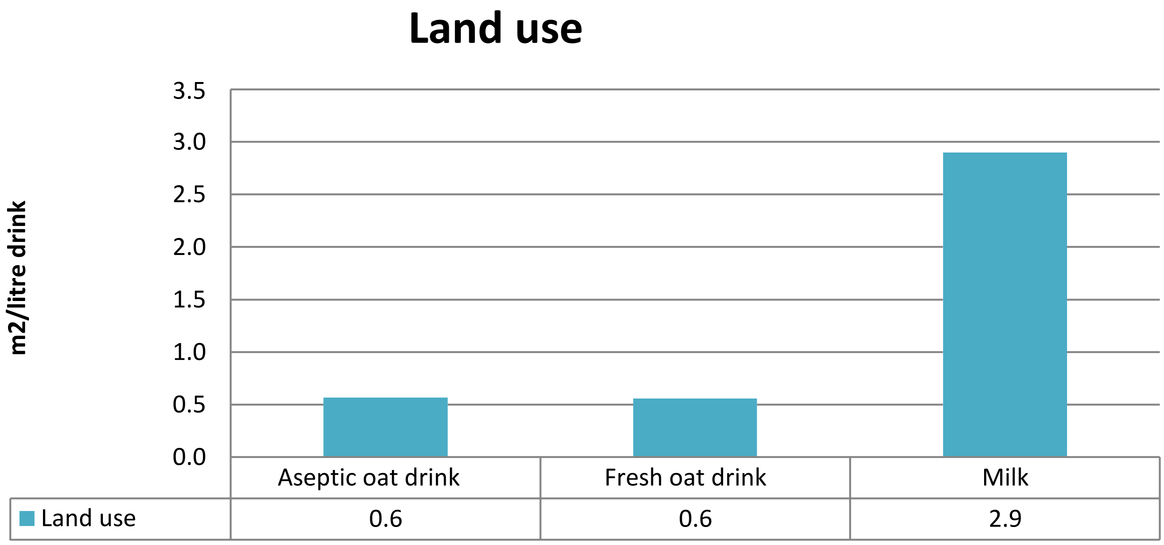


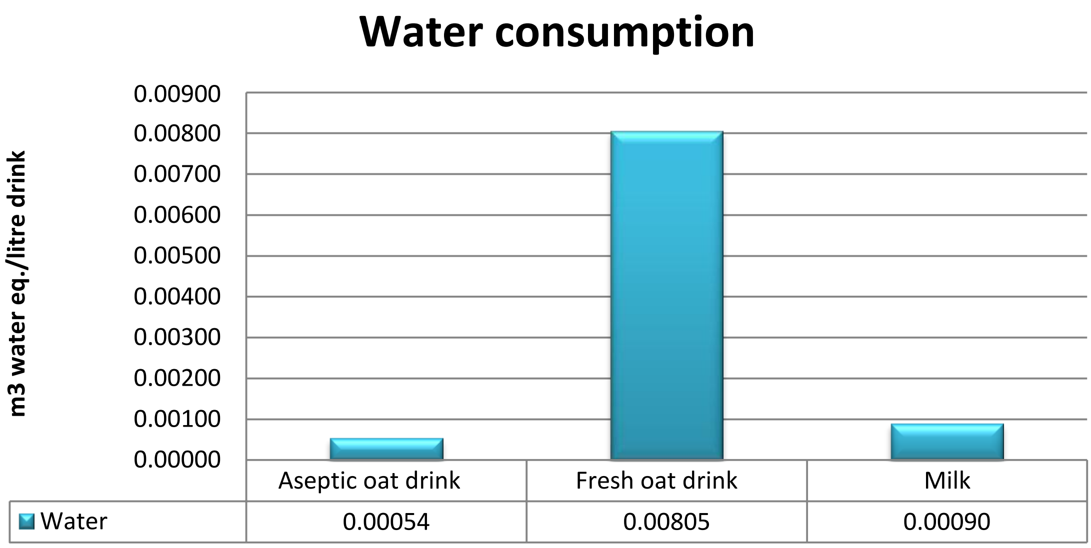
	Aseptic oat drink	Fresh oat drink	Milk
Freshwater eutrophication	0.00010	0.00019	0.00008


Marine eutrophication
kg N eq./litre drink
0.0070
0.0060
0.0050
0.0040
0.0030
0.0020
0.0010
0.0000
Aseptic oat drink
Fresh oat drink
Milk
Marine
0.0022
0.0023
0.0061


Acidification
mol H+ eq./litre drink
0.0250
0.0200
0.0150
0.0100
0.0050
0.0000
Aseptic oat drink
Fresh oat drink
Milk
Acidificatio
0.0015
0.0019
0.0236


Tropospheric ozone formation
kg NMVOC eq./litre drink
0.0050
0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Aseptic oat drink
Fresh oat drink
Milk
Tropospheric ozone
0.0011
0.0017
0.0043


Land use
m2/litre drink
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Aseptic oat drink
Fresh oat drink
Milk
Land use
0.6
0.6
2.9


Water consumption
m3 water eq./litre drink
0.00900
0.00800
0.00700
0.00600
0.00500
0.00400
0.00300
0.00200
0.00100
0.00000
Aseptic oat drink
Fresh oat drink
Milk
Water
0.00054
0.00805
0.00090

Results aseptic oat drink

	Oat	Transport farm to	Mill	Prod. ingredients	Incoming shipments of ingredients/pa	Production of packaging	Oatly	Transport Oatly to	Wholesale	Transport wholesale	Retail	Home	Consumer	Total	Unit
Impact on climate	0.076918052	0.00046928	0.007279	0.016261833	0.002414248	0.058255257	0.10977425	0.03125934	7.861E-05	0.006062202	0.0003379	0.062944139	0.001192957	0.37325	kg CO_2 eq.
Primary energy	0.52868688	0.00935428	0.1665867	0.187184318	0.049725945	1.70499534	3.04672269	0.62310595	0.008545	0.11232242	0.0367362	1.094070074	0.129683356	7.69772	MJ eq.
Soil eutrophication	0.001666707	1.1773E-05	-0.00014	0.000589271	6.03383E-05	0.000459917	0.00038751	0.0007842	8.842E-07	0.000159729	3.801E-06	0.000579779	1.34196E-05	0.00458	mol N eq.
Freshwater eutrophication	2.32898E-05	7.3079E-08	-8.51E-07	3.52603E-05	2.99135E-07	1.23068E-05	1.0714E-05	4.8679E-06	3.522E-08	7.03091E-07	1.514E-07	8.87762E-06	5.34514E-07	0.00010	kg P eq.
Marine eutrophication	0.001822236	1.0809E-06	-8.88E-05	0.000177676	5.53604E-06	5.04033E-05	6.3551E-05	7.1997E-05	8.672E-08	1.46476E-05	3.728E-07	4.77721E-05	1.31613E-06	0.00217	kg N eq.
Acidification	0.000398291	2.9821E-06	-8.57E-06	0.00022033	1.57004E-05	0.000224904	0.00016154	0.00019864	3.762E-07	3.9114E-05	1.617E-06	0.00024144	5.70875E-06	0.00150	mol H+ eq.
Tropospheric ozone	0.000199139	3.5452E-06	2.266E-06	6.31583E-05	1.76718E-05	0.00019731	0.00015795	0.00023615	2.341E-07	4.55582E-05	1.006E-06	0.000212688	3.55221E-06	0.00114	kg NMVOC
Land use	0.387991	0.000011	-0.033743	0.054134	0.000119	0.192445	-0.038077	0.000731	0.000014	0.000102	0.000061	0.002445	0.000214558	0.56645	m2
Water consumption	1.23505E-05	5.0862E-07	1.552E-06	4.44381E-05	2.09183E-06	0.000252918	0.00014099	3.388E-05	5.643E-07	4.91981E-06	2.426E-06	3.63692E-05	8.56423E-06	0.00054	m3 water eq.

Results fresh oat drink

	Oat	Transport farm to	Mill	Prod. ingredients	Incoming shipments of ingredients/pa	Production of packaging	Oat base, Oatly	Transport Oatly to	Processing, Germany	Transport Germany to Oatly	Transport Oatly to	Wholesale	Transpor t wholesal	Retail	Home	Consumer	Total
Impact on climate	0.077780305	0.000475	0.00736063	0.016289118	0.005957037	0.04268872	0.00895826	0.0224596	0.157665379	0.0396193	0.0406371	0.000393	0.007881	0.0008448	0.062944139	0.001192957	0.49315
Primary energy consumption	0.534613469	0.009459	0.1684541	0.185604514	0.118929838	1.455463129	0.49404825	0.4405118	2.715277859	0.777074	0.8100377	0.042725	0.146019	0.0918405	1.094070074	0.129683356	9.21381
Soil eutrophication	0.001685391	1.19E-05	-0.0001415	0.000597907	0.000146452	0.000380941	-0.0002553	0.0005426	0.000601206	0.0009571	0.0010195	4.421E-06	0.000208	9.504E-06	0.000579779	1.34196E-05	0.00636
Freshwater eutrophication	2.35509E-05	7.39E-08	-8.602E-07	3.34692E-05	8.09048E-07	7.07552E-06	2.8099E-07	3.304E-06	0.000103365	5.827E-06	6.328E-06	1.761E-07	9.14E-07	3.785E-07	8.87762E-06	5.34514E-07	0.00019
Marine eutrophication	0.001842663	1.09E-06	-8.983E-05	0.000181446	1.34412E-05	4.3724E-05	-0.0001429	4.981E-05	0.00013542	8.787E-05	9.36E-05	4.336E-07	1.9E-05	9.321E-07	4.77721E-05	1.31613E-06	0.00229
Acidification	0.000402756	3.02E-06	-8.669E-06	0.000218136	3.76163E-05	0.0001533	-4.457E-05	0.0001385	0.000241502	0.0002443	0.0002582	1.881E-06	5.08E-05	4.043E-06	0.00024144	5.70875E-06	0.00195
Tropospheric ozone	0.000201372	3.58E-06	2.2913E-06	6.28151E-05	4.34389E-05	0.000163618	1.5938E-05	0.0001631	0.000173258	0.0002878	0.000307	1.17E-06	5.92E-05	2.516E-06	0.000212688	3.55221E-06	0.00170
Land use	0.39234	0.0000111	-0.0341208	0.055449	0.00020	0.21848	-0.07976	0.00049	0.00149	0.00087	0.00095	0.00007	0.00013	0.00015	0.00244	0.00021	0.55943
Water consumption	1.2489E-05	5.14E-07	1.5698E-06	4.24702E-05	5.64535E-06	0.00026933	4.6304E-05	2.301E-05	0.007507173	4.06E-05	4.404E-05	2.822E-06	6.4E-06	6.065E-06	3.63692E-05	8.56423E-06	0.00805

Results semi-skimmed milk

	Feed	Farm	Production of packaging	Transport farm to	Dairy	Transport dairy to	Retail	Home	Consumer	Total	Unit
Impact on climate	0.378627	0.690311423	0.039766345	0.0266244	0.099341336	0.0231416	0.000237	0.062761339	0.001022535	1.321833	kg CO2 eq.
Primary energy consumption	3.094105	1.581864598	1.659625201	0.5221982	11.12514694	0.43778537	0.025771	1.090892717	0.111157163	19.64855	MJ eq.
Terrestrial eutrophication	0.012108	0.087672197	0.000359651	0.0006432	0.000829285	0.00058244	2.67E-06	0.000578095	1.15025E-05	0.102787	mol N eq.
Soil eutrophication	7.99E-06	3.32705E-07	7.45907E-06	3.916E-06	4.59998E-05	3.214E-06	1.06E-07	8.85184E-06	4.58155E-07	7.83E-05	kg P eq.
Marine eutrophication	0.005124	0.000698841	4.00773E-05	5.905E-05	6.77393E-05	5.3448E-05	2.62E-07	4.76334E-05	1.12811E-06	0.006092	kg N eq.
Acidification	0.002982	0.018854812	0.000162747	0.0001641	0.001089006	0.00014517	1.13E-06	0.000240739	4.89322E-06	0.023645	mol H+ eq.
Tropospheric ozone	0.001398	0.000511999	0.000168157	0.0001934	0.001659756	0.00017175	7.06E-07	0.000212071	3.04475E-06	0.004319	kg NMVOC
Land use	2.719468	0.001998251	0.223311005	0.0005852	-0.04880845	0.00047894	4.26E-05	0.002437693	0.000183907	2.899697	m2
Water consumption	0.00053	9.51155E-05	0.000275973	2.728E-05	-0.0001	2.24E-05	1.7E-06	3.62636E-05	7.34077E-06	0.000896	m3 water eq.

RAPPORT

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Granskning av projektet: LCA på färsk och aseptisk havredryck Slutrapport

På uppdrag från Oatly AB, har granskning utförts på studien ”LCA på färsk och aseptisk havredryck”. SIK har genomfört studien som innefattar livscykelanalys (LCA) av två av Oatlys basprodukter; naturell berikad aseptisk respektive färsk havredryck och en jämförelse med resultatet med en livscykelanalys på mjölk. Mjölkstudien var delvis tidigare genomförd i annan studie. Syftet med studien var att öka kunskapen om havredryckernas miljöpåverkan. Resultatet kommer att användas internt hos Oatly AB och vid miljökommunikation av havredryckerna.

Livscykelanalysstudien har genomförts enligt ISO 14040. Granskningen som valts är en kritisk genomgång av studien av en LCA-expert, oberoende av LCA-studien. Granskningen har utförts enligt ISO 14044:2006. Avstämningar har utförts fyra gånger under projektets gång i en iterativ process:

1) efter genomförd Mål och Omfattning,
2) efter genomförd Inventeringsanalys,
3) efter genomförd Miljöpåverkansbedömning och Resultattolkning och
4) efter projektets genomförande som helhet.

Vid avstämningarna har metodik, data, tolkningar och transparens granskats. Skriftliga kommentarer har överlämnats tillsammans med muntlig kommunikation. Kontroll på att genomförande av åtgärderna, utfördes vid nästkommande granskningstillfälle.

1. Mål och Omfattning

Mål och omfattningen har definierats tydligt. Miljöpåverkanskategorierna som valts för att beskriva miljöpåverkan är: energianvändning, klimatpåverkan, eutrofiering (övergödning), försurning, bildning av marknära ozon, markanvändning, ackumulerad vattenanvändning samt en kvalitativ beskrivning av pesticid- användning i havreodling. Miljöpåverkan kan beskrivas på många olika sätt och ovanstående val av flera kategorier speglar detta. Det är de kategorier som är vanliga att inkludera vid beskrivning av miljöpåverkan i relation till livsmedel.

Den funktionella enheten avspeglar produktens nytta och har definierats i relation till plats i flödesschemat. De funktionella enheterna är:

- havredryck naturell aseptisk, i konsumentförpackning (1 liter), för konsumtion hemma hos konsument.
- havredryck naturell färsk, i konsumentförpackning (1 liter), för konsumtion hemma hos konsument.

Studiens omfattning har beskrivits både i text och bild genom illustration av livscyklarnas flödesschema för båda havredryckerna och mjölken. Vid fördelning av miljöpåverkan mellan korsande produkter i ett produktsystem har systemexpansion och fysikalisk allokering använts i enlighet med standarden. Avgränsningarna i studien, det vill säga det som inte ingår, har beskrivits väl.

Detta dokument får endast återges i sin helhet, om inte SP i förväg skriftligen godkänt annat.

2. Inventeringsanalys

Data för råmaterial, energi, spill, utsläpp till luft och vatten samt avfallshantering har inventerats för varje del i havredryckernas livscykel. Dokumentation av referenser, använda metoder och antagande har beskrivits utförligt. För mjölken har utgångspunkten varit att inte nyinventera utan utgå från befintlig data från SIKs egen miljödatabas.

Datakällor som använts har varit direktinsamling från personligt besök på Oatly, insamling via Oatlys egen personal, tidigare utförda livscykelanalyser, värden tagna från databaser och även muntlig konsultation av experter. Eftersom studien är en nulägesrapport behövs också data som motsvarar detta. Det har lyckats bra eftersom ålder på data håller sig inom en 10års period med tyngdpunkt på de senare åren. Geografiskt ursprung på data motsvarar verkligheten i livscyklarna förutom på viss inventeringsdata från den tyska anläggningen. Då har istället motsvarande data från den svenska anläggningen använts. Detta bedöms inte påverka resultatet nämnvärt. Som slutsats dras att data som använts är korrekta och rimliga och därför anses datakvaliteten vara god.

3. Miljöpåverkansbedömning och resultattolkning

Resultatet av varje miljöpåverkanskategori har angivits både totalt och för varje delsteg i kedjan, för havredryckerna och mjölken. Resultatet har diskuterats för var och en av de tre LCA:erna och orsakerna till de mest intressanta resultaten har specifierats. Dessutom har resultaten från de tre LCA:erna diskuterats i förhållande till varandra. För tre intressanta situationer har känslighetsanalys utförts:
- Havreodling, jämförelse med andra odlingsdata för havre.
- Vad skulle hända om den färska havredrycken också producerades i Sverige?
- Mjölk: Vad händer när vi inkluderar bidrag från förändrad markanvändning från odling av soja i sojan som ingår i kornas foder?

Tolkningarna ligger i linje med studiens mål och syfte att öka kunskapen om havredryckernas miljöpåverkan och visa på var den största miljöpåverkan uppstår.

4. Slutsats

Metoderna som använts är i enlighet med standarden och har använts på korrekt sätt vetenskapligt och tekniskt. Datakvalitén är god och när begränsningar har uppstått har detta identifierats och analyserats. Tolkningarna av resultaten återspeglar studiens mål och syfte. Dessutom är studien transparent.

Slutsatsen av granskningen av dessa livscykelanalysstudier blir därför att: Livscykelanalyserna har genomförts i enlighet med ISO 14040.

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