Greenhouse Gas Emissions Associated with Different Meat-free Diets in Sweden

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Abstract: The production of food is responsible for large share of the anthropogenic greenhouse gas emissions. There is a wide range of emissions associated with different food-groups. In particular the production of meat from ruminants causes higher emissions compared to plant-based food. This study compared two different types of meat-free diets (ovo-lacto-vegetarian and vegan) in Sweden and the emission of greenhouse gases that are connected to the aliment and beverages that are consumed in these diets. Dietary records were used to obtain real data on what food is consumed on a weekly basis. On average the food consumed by the vegan sample caused lower emissions that the food consumed by the vegetarian sample. The average vegan diet caused 591 kg CO2e per year whereas the average vegetarian diet caused 761 kg CO2e. The annual difference is thus 170 kg. These findings are in line with existing research although recent studies often used hypothetical diets instead of real data.

Keywords: Sustainable Development, climate change, greenhouse gas emissions, diet, vegetarian, vegan

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Summary: It is very likely that there is a connection between the emission of greenhouse gases and climate change, or global warming to be specific. A large part of these emissions can be linked to the production of food for human consumption. Different foods cause vastly different amounts of emissions: Meat from ruminants like cattle or sheep is usually associated with the highest emissions per kilogram product, whereas plant-based food such as fruits, vegetables or grain causes comparably low emissions per kilogram. Some studies have therefore compared average diets of people consuming meat on the one hand and vegetarians on the other hand (usually ovo-lacto-vegetarians = people that do not consume meat and fish but dairy products and eggs). They concluded that vegetarian diets cause lower emissions than diets containing meat. So the next step could be to look at the differences in greenhouse gas emissions between different meat-free diets. This is exactly the purpose of this paper. Therefore vegetarian and vegan participants in Sweden were asked to write down what food and drinks they consumed for the period of one week. Based on these reports the emissions caused by each individual diets were calculated. The average vegan diet caused 591 kg CO₂e per year whereas the average vegetarian diet caused 761 kg CO₂e. The difference per year is thus 170 kg. This difference is smaller than the difference between a vegetarian diet and one containing meat.

Keywords: Sustainable Development, climate change, greenhouse gas emissions, diet, vegetarian, vegan

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1. Introduction

In every discussion about Sustainable Development there is one term that will most likely come up sooner or later: climate change. The notion that human actions are significantly altering the climate on a scale of decades – provocative as it might be at first – has entered public awareness. For an overview of how climate change is perceived by the public in Europe and the USA see for example Lorenzoni and Pidgeon (2006). But also on an international political scale climate change is a relevant issue. In 1992 the United Nations negotiated the Framework Convention on Climate Change (UNFCCC) with the objective to stabilize “greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system” (United Nations 1992). Since 1995 the member states have met every year to negotiate further treaties like for example the Kyoto Protocol.

Agricultural food production is responsible for a large proportion (30 to 35 per cent) of anthropogenic greenhouse gas (GHG) emissions (Foley et al. 2011) that are in return “very likely” linked to global warming (IPCC, 2007a). Within the agricultural sector different practices are causing more or less GHG emissions with the result that GHG emissions associated with different end products (i.e. different foods) vary greatly depending on how the food was produced. Animal products are usually associated with higher emissions than plant-based food. In particular the production of meat from ruminants like sheep, goats and cattle causes high emissions because these animals produce methane as a by-product of their digestion (Carlsson-Kanyama and González 2009).

This suggests that in order to reduce the GHG emissions associated with food – at least on an individual level – one should reduce or abolish the consumption of these GHG intensive products. Several studies have addressed this issue and compared meat-based diets (Berners-Lee, et al. 2012; Meier and Christen 2012) and in some cases specific meals (Carlsson-Kanyama and González 2009; Davis et al. 2010) with vegetarian alternatives. They reached the conclusion that GHG emissions or the potential for global warming (depending on the scope of the study) are lower in diets/meals that do not contain meat.

Carlsson-Kanyama and González (2009) compared three possible meals with comparable nutritional values and found that the meat-free alternative caused the lowest emissions. Furthermore the most GHG intensive meal caused eleven times the emissions compared to the least GHG intensive meal. This shows the potential for a reduction of GHG emissions on an individual level. It should be noted though that these meals are not necessarily representative and the overall range of emissions (when comparing whole diets) is probably not that large.

However, so far only a few studies have investigated in more detail the differences in GHG emissions among individual meat-free, vegetarian or vegan diets. In the few existing cases, the diets have mainly been based either on official recommendations for the particular type or on theoretical constructions (Eshel and Martin 2006; Berners-Lee, et al. 2012; Meier and Christen 2012). To what extent these scenarios represent the composition of meat-free diets in real life is uncertain. This report will therefore investigate whether there are significant differences in GHG emissions among individual diets that do not contain meat.

Other research objectives of this study are to:

- describe the composition of meat-free diets in Sweden based on a sample of dietary records
- identify the main contributors to climate change within these diets
- compare vegetarian and vegan diets in terms of GHG emissions
- determine on what factors these differences (if there are any) depend. Is it the amount or the type of intake that plays a more significant role?
2. Background

2.1 Climate Change

According to a report published by the Intergovernmental Panel on Climate Change (IPCC, 2007a), the concentration of carbon dioxide (CO$_2$) – one of the most important anthropogenic greenhouse gases (GHG) – has risen significantly since the beginning of industrialisation: from around 280 parts per million (ppm) to almost 380 ppm in 2005. This is a much higher value than what has ever been encountered naturally over the last 650,000 years. The highest value within that range has been diagnosed from ice cores to be around 300 ppm. The report further states that the main reason for these increased values is the burning of fossil fuels whereas changes in land-use play a smaller but still significant role.

For methane (CH$_4$) the researchers found that since the beginning of industrialisation emissions rose from 715 parts per billion (ppb) to 1774 ppb in 2005. Again this value goes well beyond the data found in nature during the last 650,000 years. Within that time values ranged from 320 to 790 ppb. The IPCC states (2007a) that “it is very likely that the observed increase in methane concentration is due to anthropogenic activities, predominantly agriculture and fossil fuel use”. Concentrations of nitrous oxide (N$_2$O) accumulated from 270 ppb to 319 ppb. When it comes to the anthropogenic part of these N$_2$O emissions (which accounts to more than one third according to the report) agriculture plays a main role.

At the same time the average global temperature is rising as well. In the century 1906 to 2005 the authors determined in the IPCC report (2007a) an increase in mean global temperature of 0.74°C. The paper states: “Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations.” As a consequence glaciers, ice and snow in general are melting which leads to rising sea levels. On average the global sea levels were rising by 1.8 mm a year from 1961 to 2003. During the last ten years of that measurement the rise was even higher with 3.1 mm a year. This increase can “very likely” be linked to the decline of the ice sheets of Greenland and Antarctica (IPCC, 2007a). If this trend is to continue the consequences will be severe especially for low-lying, flood prone countries in coastal areas.

Global warming will probably also affect food security in many countries. Higher temperatures will increase water shortages and decrease agricultural productivity especially of cereal productivity in low altitudes. Increased malnutrition will be the implication. Ecosystem disruption and the widespread extinction of plants and animals is another risk that has to be considered. If the rise in mean temperature goes beyond 1.5 – 2.5°C between 20 and 30 per cent of the known plant and animal species are likely to be at risk of extinction (IPCC, 2007b). In its conclusion the IPCC (2007a) states: “Continued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would very likely be larger than those observed during the 20th century.”

2.2 Food production and GHG emissions

Agricultural food production accounts for a large fraction of the current GHG emissions. A study recently published in Nature estimates that around one third of the GHG emissions every year are due to the agricultural sector (Foley et. al. 2011). There are several practices within agricultural production that are mainly responsible for these emissions. The authors evaluate that this is the case in around 80 per cent of newly developed cultivable area. This is not only alarming because these forests are important ecosystems that inhabit many plant and animal species, the trees also work as a natural carbon storage. Once the trees decompose or the wood is burned, this carbon is released to the atmosphere as CO$_2$. According to the study this practice of replacing tropical forests with agricultural land is responsible for around 12 per cent of the anthropogenic CO$_2$ every year. Other emissions of CO$_2$ at that stage arise from agricultural machines where the engines are powered by the burning of fossil fuels and the production of fertilizers. (Garnett 2011)

Nitrous oxide (N$_2$O) emissions are closely linked to the widespread application of Nitrogen based fertilizers. More than one half of the worldwide crop plants are fertilized on a regular basis (Vergé, De Kimpe and Desjardins 2007). First N$_2$O is emitted during the production of synthetic nitrogen based fertilizer holding...
nitrate, e.g. ammonium nitrate. Later, after the fertilizer has been applied, parts of the Nitrogen get released by the farm land as N₂O (Carlsson-Kanyama 1998). Another agricultural source of N₂O emissions is the livestock-sector. Here manure and urine are identified as contributors and also the use of synthetic fertiliser in feed crops (Garnett 2011).

Methane is produced during the digestion of ruminant farm animals (like sheep, goats and cattle) and when animal manure is stored in anaerobic conditions. Another CH₄ source is the cultivation of rice. Here the gas is emitted when the fields are flooded because organic materials then ferment while decomposing in the soil (Carlsson-Kanyama 1998). As a result the agricultural food production accounts for around half of the anthropogenic CH₄ emissions and up to 70 per cent of the anthropogenic N₂O emissions. (Vergé, De Kimpe and Desjardins 2007). These numbers are not that surprising if one keeps in mind that both CH₄ and N₂O are connected to animal husbandry and the majority of the agricultural area – about three quarters – are used to raise animals either directly as grazing area or indirectly because the cultivated crops are used as animal fodder. (Foley et. al. 2011)

After the agricultural production stage, CO₂ is the main GHG associated with the food sector. Emissions are mainly connected to the usage of fossil fuels for manufacturing, transportation, packaging, distribution, storage, waste disposal, retailing and preparation by consumers at home. A smaller but still significant fraction arises from refrigerant emissions (Garnett 2011). However, another study published in the USA found that these post-production processes play only a minor role in the overall emissions of GHG. (Weber and Matthews 2008) The authors conclude that the lion’s share of 83 per cent of all food related GHG emissions are associated with the production stage.

It has been argued (FAO 2012) that the potential for a reduction of GHG emissions that lies within the agricultural sector is recognized by some policy makers. To state one example: the government of Vietnam is investigating methods to make rice cultivation more sustainable and thereby reduce the methane emissions. Also the approach of “Climate-smart agriculture” broadly defined as a compromise between crops, livestock, forestry and fisheries is described as something that should be implemented in order to make agriculture more sustainable and “reduce and remove greenhouse gases.” (FAO 2012)

2.3 LCA to measure emissions of foods

One way to measure the GHG emissions associated with different foods is to use the methodology of life cycle assessment (LCA) which is based on following life cycle use of resources and emissions, i.e. a cradle to grave perspective. LCA are not only used to estimate emissions in the food sector, they are a basic tool to measure environmental impacts of certain goods or actions. The idea is to take into account all different stages during which a product has environmental impacts (these stages could for example include production, transport, usage, disposal as waste etc.) and measure these impacts quantitatively. Hence the name life cycle assessment. In the end all the particular impacts get summed up so that the total environmental impact of the product can be estimated. (Roy et. al. 2009).

These methods and life cycle thinking is also used in tools for carbon footprint accounting. One example for such a tool is the PAS 2050 from British Standards Institution (2011). It is free available and provides business and organizations with a standardized method to measure the GHG emissions of the goods and services that are offered. The goal is that organizations are able to consider climate change impacts “beyond their own corporate activities”, arising for example from their supply-chain (British Standards Institution 2011).
2.4 GHG emissions associated with different foods

As shown above, agriculture in combination with the whole food sector contributes to a large extent to the emissions of anthropogenic GHG. But within this sector there are differences between different food groups. Animal products especially meat of ruminants such as cattle and sheep usually cause higher emissions – up to 30kg CO$_2$e per kg product – than plant based foods. A selection of plant based foods and their correlating emissions are listed in the table below. Concentrated dairy products such as cheese and butter also cause multiple times the emissions compared to fruits, vegetables and cereals. One exception are exotic fruits and vegetables with a short shelf-life that therefore have to be transported by plane. These fruits and vegetables have very high emissions (14kg CO$_2$e per kg), indeed higher than dairy products or eggs. (Ekström 2012)

![Figure 1. Emissions of some selected food items. The blue bar shows absolute emissions in kg CO$_2$e per kg product. The red bar shows the emissions adjusted for energy in g CO$_2$e per kcal. The emission-values were taken from Ekström (2012).](image)

2.5 Other environmental impacts of food production

But of course, the emission of GHG is only one possible impact and there are other environmental impacts that have to be considered. Some studies have been published over the last years that compared different environmental impacts of different dietary patterns or individual meals (Baroni et. al. 2006; Reijnders and Sam Soret 2003; Marlow et. al. 2009). The described environmental impacts include: ecotoxicity, acidification and eutrophication, land use, energy consumption, chemical fertilizer application, pesticide application, waste generation, land degradation and others. In the results, the authors suggest that a vegetarian/vegan diet or plant-based meals (depending on the alternative scenario discussed in the particular study) is better in environmental terms compared to an omnivore/average diet.

A similar conclusion was reached by Pimentel and Pimentel (2003). They analysed the resource-efficiency of the average American diet compared to an ovo-lacto-vegetarian (containing eggs and dairy but no meat, fish or sea food) diet. In conclusion they suggest that an ovo-lacto-vegetarian diet is more sustainable than the average American diet insofar that resources such as land, energy or fresh water are used more efficiently.
3. Methods and Methodology

3.1 Methodology

One goal of this study is to use real-life data in order to get an understanding of what meat-free diets look like in Sweden. Potential methods to obtain such data are the 24-Hour Dietary Recall or the Food Record Method, because they are both based on what individuals actually consume (Willett 1998). For the 24-Hour Dietary Recall the participants meet with a trained interviewer and describe in detail what they consumed over the last 24 hours. The advantage of this method is that the food will be recorded by a person that received training or instructions and is therefore familiar with the extent of accuracy that is needed for the goal of a particular study. The record can thus be conducted in a way that is most suited for the later analysis. The interviewer has always the possibility to require more detailed descriptions if necessary and can in general record the food intake in a way that keeps time consuming conversions at a later point to a minimum. The disadvantage is obviously that the exactness of the data is very dependent on the memorization of the participants. The fact that participants estimate the size of the consumed portions places some restrictions if the results are to be used in a quantitative way (Willett 1998).

This dependence on the participant’s memory is minimized if instead the food record or food diary method is used. Here the participants (or in some cases an observer) record the food intake at the time it is consumed. They also have to measure the amount of food consumed which differs from the 24-Hour Dietary Recall, where the portion sizes are estimated. If the study in question involves a large number of participants it is usually not possible to have an observer that is recording the food intake of every participant. In that case it is crucial that the participants get proper instructions and are familiarized with the intended purpose of the records. Otherwise the records might be incomplete or inaccurate. But even if proper instructions have been given to the participants, it is still important to review to records immediately after completion in order to see if they are appropriate enough for their purpose. If not the participant in question can be contacted for further details while his or her memories are still fairly fresh. If too much time lies between the completion and the review of the record, it might not be possible to get any clarification simply because the participant cannot remember accurately enough.

One disadvantage though is that the food record might be quite bothersome for the participants since they have to measure every meal before they consume it. A result might be that participants wait several hours before they write down what they consumed thereby relying on their memory which might introduce some uncertainties. Another consequence might be that participants change their eating habits in order to simplify the recording. They might choose more simple meals with less ingredients instead of more complex ones or they might change their eating patterns towards what they think is desired for the study (for example more healthy food than usual or in this case food that they think causes lower emissions). It is therefore important to have a high level of commitment and motivation on the part of the participants. On the other side it is this troublesomeness that makes this method more suitable for the purpose of this study. Since the calculations of emissions are based on the weight of a particular food, it is important that all the meals are measured in a way that can be expressed quantitative (Willett 1998).

GHG emissions are usually expressed in CO$_2$-equivalents (CO$_2$e). This is a comparative unit that includes the global warming potential (GWP) of several GHG, among them CH$_4$, N$_2$O as well as CO$_2$. GWP is an index that expresses the warming potential of a specific gas or a mix of gases over a defined period of time (usually 20, 100 or 500 years). CO$_2$ works as a reference gas with a defined value of one whereas all other GHG are expressed as factors of that (Carlsson-Kanyama and González 2009; Forster et. al. 2007). The emissions used in this study are based on a 100 year period. That means CO$_2$ has a GWP of 1, CH$_4$ of 25 and N$_2$O of 298 (Ekström 2012). So for example in order to calculate the according value of CO$_2$ equivalents for N$_2$O emissions, the particular emissions have to be multiplied by 298.
3.2 Study design

For the reasons stated above the method chosen for this study was the food record. Willett (1998) suggests that it is also significant on which day of the week a record is conducted since the overall consumption of food might differ for different days of the week. To address this issue and also in consideration of the fact that the number of 25 participants in this study was rather small, it was decided that every participant should record a whole week. Therefore vegetarian or vegan participants living in Sweden had to be found that recorded their food intake for the time of one typical week. In order to reach a high number of participants potentially interested in contributing in such a study several approaches were used. Emails were sent through the personal network of potentially interested people. They were also asked to forward the mail through their network and so on. This is known as Snowball sampling in social science (Heckathorn 2011).

In addition an ad was posted in relevant groups of the platform couchsurfing.org. At the same time, a facebook group was created in order to reach appropriate groups on this social network. In all three cases a description of the study goals and the expected contribution of participants was provided. In order to participate people were asked to state their interest in a mail and also provide some basic information about themselves. These information included age, gender, educational level and whether they are pregnant or have children. In case there were more interested people than the number of intended participants, these information would have been used to design the most diverse sample. In the end this did not occur so that every person that provided a diet record in time (9 persons withdraw their initial attendance) is included in the study. In total the data of 25 participants is used.

After their initial mail the interested persons were once again provided with a description of the purpose of the study. Further on they received instructions on how to fill out the dietary record and a form that they could use, including an example-day. It was also stated that in return for their participation the results will be shared with the participants. That means every participant will be informed about the emissions caused by her or his individual diet and every participant will receive an electronic exemplar of this study. The reader was also informed that all data will be handled confidential and that it is possible to refuse or withdraw contribution at any point. The letter that was sent out can be found in Appendix 1, the record-format including the example-day in Appendix 2.

The analysis of the data started with the calculation of the total emissions of CO₂-equivalents for every particular food record. However, differences in these absolute numbers are not necessarily solely related to high GHG emissions of single foods. They could also have been based on differences in energy-intakes. Depending on factors such as weight and level of activity every participant has a specific basic metabolic rate and an equivalent energy consumption. In other words higher emission-rates could mainly correlate with higher intakes of calories rather than differences in food choices. In order to take this factor into account and make the numbers comparable, the total amount of kilo-calories in every record was calculated as well so that the average CO₂-equivalent per kilo-calorie (CO₂e/kcal) ratio in every diet could be established (see below for a more detailed description of the calculations). That way potential under- or over-reporting was also more balanced in terms that the amount of energy taken in became less important, because it was also taken into account.

After that the participants were divided into two groups: vegans (12 participants that consumed neither meat, fish, dairy or eggs) and vegetarians (13 participants that did not consume meat or fish but other animal products such as dairy and/or eggs). A further division into subcategories such as lacto-, ovo- and ovo-lacto-vegetarian has been considered but has in the end not been realized because of the small sample.
3.3 System boundaries of LCA data

Different LCA studies might have different system boundaries, i.e. stations of a products life cycle that are accounted for and measured in the end. The LCA used to calculate the GHG emissions in this study included the following stations (Ekström 2012):

- inputs to agriculture
- agriculture
- food industry/processing
- distribution/warehouse
- retail

Emissions from land use changes such as deforestation were not included. Nor were emissions included that arise at home for example from storing or preparing the food. These emissions are difficult to account for since they depend on a lot of unknown variables such as the type or energy-efficiency of the used devices and individual cooking habits. Transportation to the supermarket and back (i.e. when people purchase their food) are not included. A factor for food that gets wasted at homes has been included. Also unavoidable waste from food preparation (for example shells or cores of fruits) has been accounted for. However, potential emissions from waste management are not included in the LCA data (Ekström 2012).

3.4 Calculations

The calculations of the CO₂e emissions are based on data from different LCAs that have been collected and adjusted by Ekström (2012). The calculations were done manually, so every food has been multiplied with its corresponding emissions. After that all the emissions have been summed up to obtain the total emissions for the particular dietary record. In a few cases only the total weight and a list of all ingredients was available for a specific meal. That was usually the case when participants were eating out or have not prepared the food themselves. In these cases the proportion that the single ingredients have of the whole meal are based on reasonable assumptions.

Some participants did not possess a kitchen scale but they still wanted to be part of the study. In that case they stated the volume for stable food like rice, lentils, oats etc. and the amount of fruits or vegetables consumed. Since the measurement in volume (especially decilitres) is still commonly used in Sweden, all of the participants without a scale possessed measuring jugs in different sizes. The volume of the particular food has then converted with a kitchen scale. For a list of all food where this applied see Appendix 3. For fruits and vegetables average weights could be obtained from a study conducted by the Federal Office of Consumer Protection and Food Safety in Germany (2002).

The calculation of the energy-intake has been done in the same manner and is based on a database of the US Department of Agriculture (2011). Since the database holds several entries for similar aliment based on different forms of preparation and/or variations in the ingredients (there are for example more than 100 entries for bread to choose from) one representative entry of the database has been chosen for every major aliment that occurs in the dietary records. Every particular food has then been multiplied with the corresponding value of the database to determine its energy. After that they have been summed up to determine the total energy of the particular record. In total 120 entries of the database have been used.
4. Results

4.1 Characteristics of participants

The characteristics of the participants are shown in the table below. 64 per cent of the participants were women and 64 per cent of all participants were between 20 and 29 years old. The remaining 36 per cent were between 30 and 39 years old. The level of education was very high, 92 per cent had university education.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Men (n=8)</th>
<th>Women (n=17)</th>
<th>All (n=25)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>20 – 29</td>
<td>5</td>
<td>63</td>
<td>11</td>
</tr>
<tr>
<td>30 – 39</td>
<td>3</td>
<td>38</td>
<td>6</td>
</tr>
<tr>
<td>Student or holding university degree</td>
<td>7</td>
<td>88</td>
<td>16</td>
</tr>
</tbody>
</table>

Table 1. Characteristics of participants

4.1.1 Characteristics vegan group

Based on their diet records, 12 participants were assigned to this group. 67 per cent (8 out of 12) were between 20 and 29 years old whereas the remaining 33 per cent (4 out of 12) were between 30 and 39 years old. The group consisted of 67 per cent (8 out of 12) women and 33 per cent (4 out of 12) men. Two participants in this group described themselves as being “as vegan as possible” which means they purchase and consume ovo-lacto-vegetarian food occasionally. In addition to that two participants stated to never buy food containing animal products for themselves but occasionally consume ovo-lacto-vegetarian food if offered. During the time of the record no participant in this group consumed any dairy products and/or eggs. 25 per cent (3 out of 12) within this group had one or more children, one of these 25 per cent was pregnant at the time of the recording. The majority of 83 per cent (10 out of 12) were students or already hold a university degree, the remaining 17 per cent (2 out of 12) were employed without holding a university degree.

4.1.2 Characteristics vegetarian group

13 participants were assigned to this group. 62 per cent (8 out of 13) of the participants were between 20 and 29 years old. The remaining 38 per cent (5 out of 13) were between 30 and 39 years. As in the vegan group the majority of participants in the vegetarian group were women: 69 per cent or 9 out of 13. Two participants considered themselves “flexitarians”. That means they eat meat or fish – although rarely – for practical reasons or on special occasions (as stated for example “Grandma’s Christmas roast”). Furthermore one participant stated to eat seafood about once a month. None of the participants consumed meat, fish, seafood or products containing either of the three during the time of recording. The level of education was even higher than in the vegan group: All of the participants in this group were either studying towards or already holding an university degree.
4.2 Energy intake and composition of the diets

The average energy intake during the seven recorded days was 15444 kilo-calories (kcal.) or around 2200 kcal. per day and participant. This number is a realistic daily intake as it accords more or less with official recommendations (USDA/ USDHHS 2010) for people between the age of 20 and 40.

4.2.1 Vegan diet

The average energy intake was almost equal in both groups. The vegans consumed on average 2213 kcal. per day which is only slightly higher than the average for all participants. The composition of the average vegan diet can be found in the graph below. The majority of energy was provided by stable foods like cereals (as for example oats, bread, pasta etc.), pulses (beans, lentils etc.) and sources of vegetal fat such as nuts, seeds and oil. These three groups combined supplied 70 per cent of the energy consumed in the vegan group. The remaining 30 per cent of the total energy was distributed among fruits, vegetables and luxury food such as sweets, crisps, fast food and beverages. The distribution between these three groups was almost evenly, although the share of luxury foods was slightly higher than fruits and vegetables.

![Composition of the average vegan diet](Image)

4.2.1 Vegetarian diet

The energy intake in the vegetarian group was accordingly slightly lower than among the vegan group and accounted exactly 2200 kcal. per day. As in the vegan sample cereals (oats, bread, pasta etc.), pulses (beans, lentils etc.) and vegetal fat (nuts, seeds and oil) provided more than half of the total energy. These three account for 58 per cent, which is lower than in the vegan sample. Therefore dairy products and eggs provide another 11 per cent of the energy. That leaves almost the same share (32 per cent) for fruits, vegetables and luxury food (beverages, fast food, sweets etc.) as in the vegan group (30 per cent). Although in the vegetarian sample luxury foods had a higher share and fruits and vegetables accordingly a lower share of the energy compared to the vegan sample.
4.3 Emissions

At the same time the emissions throughout the whole sample (meaning both vegetarians and vegans included) averaged around 1.85kg CO$_2$e per day. When adjusted to the average energy intake, the emissions are 0.84g CO$_2$e per kcal.

Differences between the two groups could be assessed and were more evident compared to the energy intake. The average vegan record caused 1.62kg CO$_2$e a day or 591kg per year. That results in energy adjusted emissions of 0.73g CO$_2$e per kcal.

The average correlating emissions in the vegetarian group were higher, indeed around 2.1kg CO$_2$e per day or 761kg per year. The adjusted emissions for one kcal. are thereby 0.95g CO$_2$e.

That means that the difference between the two groups was 0.48kg of CO$_2$e per day. In other words: The average vegan diet in this study causes about 23 per cent less emissions than the average vegetarian diet in this study. When extrapolated to one year, the difference between having a vegan or vegetarian diet is 170 kg.
4.3.1 Vegan diet

In the vegan sample, fruits in combination with air-transported goods caused one third of all the emissions. Vegetables and cereals also each caused almost 20 per cent of the emissions, followed by pulses, luxury food and vegetal fat.

![Emissions Vegans in %](image)

**Figure 5.** The perecentaged emissions per food-group in the vegan sample.

4.3.1 Vegetarian diet

Dairy products caused the largest emissions in the vegetarian sample, followed by fruits and luxury foods. Cereals and vegetables had both lower emissions than in the vegan sample. Pulses, vegetal fats and eggs caused low emissions and aviated goods did not contribute significantly.

![Emissions Vegetarians in %](image)

**Figure 6.** The perecentaged emissions per food-group in the vegetarian sample.
4.4 Correlation between energy intake and emissions

One question this study also is supposed to clarify is whether the differences in emissions are rather based on the amount or the type of intake. In other words: What determines the amount of emissions, what or how much one eats? Figure 1 shows the correlation between emissions and the corresponding energy intake for all participants of this study. As the diagram shows the range of energy intake for similar emissions varies greatly, sometimes almost by a factor of 2. It seems that there is a significant difference between the vegetarian and the vegan sample. At least with increasing energy intake there is a variation in the correlating emissions. In the vegan group the emissions stay more or less constant while the energy-intake is rising, whereas in the vegetarian group the emissions increase with increasing energy intake. That implies that the intake among the vegetarians is more homogeneous while in the vegan sample there are some significant differences. For example only some vegans (4 out of 12) consumed products that were transported by plane. These products cause high emissions but are at the same time very low in energy (see below). However, almost all vegetarians (11 out of 13) consumed dairy products – which also cause high emissions but add less energy – on a regular basis (several times a week). The sample is to small to make general assumptions but these results imply that the type of food is more important than the amount when it comes to determine the amount of GHG emissions.

![Figure 7. CO₂e emissions in kg and the corresponding energy intake in kcal. for all participants.](image)

4.5 Emissions compared to energy intake

The graphs below show the composition of the average diet and the correlating emissions for every food group for the vegan and the vegetarian sample respectively. In the vegan group it is evident that stable foods like cereals, pulses as well as vegetal fats contribute less to the emissions compared to the share they have in total energy. The same goes for luxury foods such as sweets, crisps, fast food and beverages. Although items in this group usually have higher emissions than unprocessed food, they have at the same time a high energy density. For fruits and vegetables it is the other way around. Their share of energy is smaller than their share of emissions. This is most obvious for goods that were transported by plane. They have a significant share of the emissions but at the same time are almost not traceable in the energy-graph. That means that cereals, vegetable fat sources like nuts, seeds, oil etc. but also luxury foods provide a high amount of energy while they cause a smaller amount of GHG emissions compared to fruits and vegetables.
In the vegetarian group there is a similar picture with the exception that dairy products have the biggest share of the emissions. However when it comes to the share that dairy products have of the total energy, they rank behind cereals, vegetal fats, luxury goods and pulses.

**Figure 8.** The percentaged composition of the average vegan diet. See appendix 4 for exact numbers. Vegetal fat includes oil, margarine, nuts, seeds, peanuts etc. Luxury food includes sweets, fast food, beverages and crisps etc.

**Figure 9.** The percentaged composition of the average vegetarian diet. See appendix 4 for exact numbers. Vegetal fat includes oil, margarine, nuts, seeds, peanuts etc. Luxury food includes sweets, fast food, beverages and crisps etc.
5 Discussion

As shown in the results a difference between the vegetarian and the vegan sample in terms of GHG emissions could be determined. In the vegetarian sample dairy products cause more emissions than any other single food-group. At the same time, the share of the total energy is much lower than the share of the emissions. In both samples fruits and vegetables were also found to have a higher proportion of the emissions than they have of the energy. That was true to a larger extend for goods that were transported by plane, especially in the vegan group. In both groups cereals and vegetable fat sources like nuts, seeds etc. had a higher share of the energy than they had of the emissions.

What is original about this study is that it exclusively deals with meat-free diets in Sweden and the differences in GHG emissions between them. Also only real data accessed by individual dietary records has been used. That contributes to a clearer picture of what a vegetarian or vegan diet in Sweden might look like in reality. Because so far, mainly hypothetical or constructed diets have been used (for vegans and vegetarians) in existing studies.

5.1 Relation to other studies

Five vegetarians were participating in the study that provided the LCA data that was used to calculate the emissions in this study (Ekström 2012). The resulting average emissions for these five vegetarians (around 2.1kg CO₂e per day) are exactly consistent with the results for the 13 vegetarians in this study (as well 2.1kg CO₂e per day).

Eshel and Martin (2006) compared a hypothetical vegan diet with four different hypothetical diet scenarios. The composition of the vegan diet was not further defined but it was rather used as a baseline to which all the other diets were compared. To show differences, the amount of GHG intensive products was gradually increased in every of the four discussed scenarios. Since the vegan diet was thought to have the lowest emissions to start with the results are obviously in line with the results of this study.

In a recent study (Berners-Lee, et. al. 2012) six meat-free scenarios (three ovo-lacto-vegetarian and three vegan) were compared to the average diet in the United Kingdom. For each meat-free alternative (ovo-lacto-vegetarian and vegan) two of the scenarios were hypothetical and one was based on self-reported data from other studies conducted in the USA. Depending on the scenario, the GHG emissions of the meat-free scenarios were between 18 and 31 per cent lower than the UK-average. This is a smaller percentaged difference than the one found in the present study. The mean vegan scenario caused lower emissions than the mean vegetarian with an average difference between the two meat-free diets of 0.34kg CO₂e a day. Projected onto a year the difference would be around 124kg CO₂e.

However it should be noted that the total emissions were higher than in this study: Emissions ranged from 5.54 to 6.06 kg CO₂e per day (2t to 2.2t CO₂e per year) in the vegetarian scenarios and from 5.14 to 5.68 kg CO₂e per day (1.88t to 2.1t CO₂e per year) in the vegan scenarios. A margin that can partly be explained by the fact that these numbers are based on statistics about the total quantity of food that is available in the UK. That means they use the amount of food consumed plus the amount of food that is lost or wasted at any point after its production. This results in a daily allocation of 3458 kcal. per person, compared to around 2200 kcal. that are consumed in this study. In addition they included emissions from land use change (for example deforestation) which were not included in the LCA used for this study (Ekström 2012).

Meier and Christen (2012) conducted a similar study in a German population. They used five different scenarios: The average annual consumption in Germany in 2006, two officially recommended diets (one by the German Nutrition Society, the other by the Federation for Independent Health Consultation) as well as an ovo-lacto-vegetarian and vegan scenario. Both the vegetarian and the vegan diet were based on recommendations by the USDA, thus hypothetical. The main difference between the vegetarian and the vegan scenario was, that dairy products were replaced by “vegan milk products” and instead of butter and eggs the vegans were assumed to consume slightly higher amounts of nuts, seeds, legumes and vegetal oils. However the amount of cereals, fruits, vegetables and sugar was exactly the same whereas in the present study some differences in these food groups could be assessed. As the results above show, the vegetarians consumed lower amounts of fruits, vegetables and cereals and higher amounts of luxury foods as the vegans.
The daily intake in every scenario was defined as 2000 kcal. In the results the vegan scenario was estimated to cause the lowest emissions (2.63kg per day or 0.96t per year) followed by the ovo-lacto-vegetarian scenario (4.27kg per day or 1.56t per year). That means there is a difference of 38 per cent between the two meat-free scenarios which is a greater difference compared to the findings of the present study (23 per cent). This discrepancy can be explained by the high intake of dairy products in their vegetarian scenario. When they defined their dietary scenarios, the consumption of a particular food group was expressed in a specific weight that was assumed to be consumed (instead of the consumption of energy which is used in this study). Out of the total consumed weight, around 40 per cent (740g/1857g) were assumed to come from dairy. Other than 8g butter this group was not further defined. Even if the 732g dairy consisted only of milk (which has the lowest energy content in this group), dairy products would already provide 430kcal or 22 per cent of the total energy, while in the present study dairy products provide only 9 per cent of the energy. If some of this milk was replaced by products with a higher energy content such as cream or cheese – as would be realistic – the share of the total energy would be even higher. That high percentage also explains why dairy products make up more than half of the emissions in their vegetarian scenario.

As for the three remaining scenarios, the two recommended diets were both estimated to cause around 5kg CO$_2$e per day/1.8t CO$_2$e per year while the actual German diet resulted in 5.62kg CO$_2$e per day/2.05t CO$_2$e per year. Other than in the study discussed above (Berners-Lee, et. al. 2012) this time the energy intake of 2000kcal. was on a comparable level. On the other hand there were methodological differences in the LCA data. They included for example transportation to and from retail and emissions from land use in the estimation of GHG emissions which are not included in this study.

![Annual CO2e emissions in t](image)

**Figure 10.** The range of emissions as found by the studies discussed above. The orange bars show the results of Berners-Lee et. al (2012), the black bars show the findings of the German study by Meier and Christen (2012). The blue bars show the result of Ekström (2012) and the findings of this study.

The range in the resulting emissions suggests that there are some uncertainties when it comes to the actual amount of emissions caused by different diets. One should consider the methodological differences between studies before comparing the results. Some examples for these differences could be that a higher or lower intake of energy is assumed, potential under-reporting has been compensated or variations in the system boundaries of the LCA methodology that is used to calculate the emissions. Although the general trend is rather clear and shows that the results of this study are in line with existing research.
5.2 Comparison to other diets

Ekström (2012) conducted a study about the average GHG emissions caused by the diets of 177 individuals living in Sweden. The calculations are based on the same LCA methodology as in this study, so that the results can be related to each other. The average diet in Ekström’s study caused 1.4t of CO₂e per year with a high variation between individual diets. A comparison to the annual emissions of 0.76t in the vegetarian sample and 0.59t in the vegan sample in this study implies that the diet related GHG emissions could potentially be reduced on an individual level by more than half by a dietary shift.

Ekström divided her sample into different subcategories to determine differences in emissions between different dietary models. Two of them are presented in the graph below together with the two meat-free alternatives examined in this study. Most of the participants were assigned to the group “omnivores with beef” which means that meat – including beef – is part of their diet. “Omnivores without beef” accordingly means that meat in general but not beef is part of the diet.

A shift from an omnivore diet containing beef (annual emissions around 1.5t) to an omnivore diet without beef (annual emissions around 1.1t) would reduce the annual emissions by around 0.4t; a shift to a vegetarian diet even by 0.73t compared to the difference of 0.17t between the two meat-free diets described in this study. That means that the absolute potential to reduce GHG emissions on an individual level could be greater within an omnivore diet (if one reduces the amount of beef significantly) than it is within meat-free diets (by a shift from a vegetarian to a vegan diet).

![Graph showing annual emissions of different dietary models](image.png)

**Figure 11.** Annual emissions of different dietary models. Data for the two omnivore scenarios are taken from Ekström (2012).
5.3 Context of results

The results of this study can also be related to the total annual GHG emissions per person in Sweden. These emissions were estimated to be around 6.7t CO₂ in 2011 (European Environment Agency 2012). If the four scenarios discussed above are related to this number, the following proportions of the annual GHG emissions per person in Sweden can be obtained:

- The 1.4t CO₂ caused by the Swedish average diet (Eksström 2012) represent 21 per cent
- The vegetarian average in this study of 0.76t CO₂ equals 11.3 per cent
- The vegan average in this study of 0.59t CO₂ equals 8.8 per cent

An average car emits around 263g of CO₂ per km (U.S. Environmental Protection Agency 2011). Note that such a car also emits other GHG such as CH₄, N₂O and air conditioning refrigerants. However these depend on a variation of factors and are hard to account for. However, they cause only 1 to 5 per cent of the total GHG emissions of a car (adjusted for global warming potential) and are thus negligibly in this example. If only the CO₂ emissions are considered, an annual difference of 170kg CO₂ equals to a car drive of 650km. This is roughly the distance between Copenhagen and Stockholm.

On a long distance flight (defined as more than 463km) within Europe, a plane emits on average 149g CO₂ per km and passenger (LIPASTO 2009a). These emissions per passenger should not be confused with the example above where the car as such emits 263g CO₂ per km. If several people were travelling in the car, the emissions per passenger would also be accordingly lower. That means that the annual difference of 170kg CO₂ is equal to a long distance flight of 1140km. That represents roughly a flight from Frankfurt am Main to Stockholm.

An Intercity electric train emits on average 15g CO₂ per km and passenger (LIPASTO 2009b). Again, this is not to be confused with the car-example. An annual difference of 170kg CO₂ accord 11303 km spent in such a train. This more or less correlates with eighteen trips from Copenhagen to Stockholm.

5.4 Limitations

There are some limitations in this survey that one should note. First of all the self-selected sample with 25 participants is rather small and probably not representative for the whole vegetarian/vegan part of the population. Also it is very homogeneous: No participant is older than 40 and almost all of them have a high level of education (either holding or studying towards an university degree). The data assessment with dietary records poses some uncertainties. Under- or over-reporting is a common problem when individuals measure their food intake. According to Willett (1998) in different groups of participants under-reporting will vary but might be as high as 20% in some groups. This has not been addressed in this study.

Even though the participants were asked to report their intake during a typical week it is still a short time period that might not represent the usual eating habits. For example all the records were taken during winter but lifestyle and eating patterns might be different during spring or summer. The very activity of keeping a dietary record might change how and what people eat. They might skip little snacks or choose simple recipes (with less ingredients) instead of more complex ones in order to simplify the recording. Also eating out or in general food that has not been prepared by the participants themselves might result in some uncertainties since it is possible that not all necessary details can be assessed by the participants (Willett 1998). In this study, the total weight and a list of the ingredients was always available for every meal that the participants did not prepare themselves. In these cases assumptions had to be made about the proportion a particular ingredient had of the whole meal. This is especially uncertain when meals potentially contain significant amounts of water such as stews or soups. However these assumptions were only necessary in exceptional cases, usually not more than two or three meals per record if at all.

The records did usually not include a description of how the meals were cooked or prepared. This introduces some further uncertainties since the usage of energy and thereby the emissions might differ depending on individual cooking habits (for example how long the food is cooked or how many portions are cooked every time). Furthermore, there are some uncertainties associated with the usage of LCA. Ekström (2012) elaborated on the uncertainties that apply for the LCA data used in this study. Lastly, some uncertainties might be involved.
due to the fact that all the calculations have been done manually in spread sheets.

5.5 Strengths

A major strength of this study is that exclusively deals with data that has been obtained from personal dietary records. It is thus possible to study differences in GHG emissions between individual dietary choices. Previous studies usually rely at least partly on hypothetical diets (Berners-Lee, et. al. 2012; Meier and Christen 2012; Eshel and Martin 2006) or compare individual dishes (Carlsson-Kanyama and González 2009; Davis et. al. 2010). Since until now, such a comparison has not been done in the current form (at least not in a Swedish population), this study provides new knowledge about the composition and the resulting GHG emissions of ovo-lacto-vegetarian and vegan diets in Sweden.

When it comes to the concision of the dietary records the fact that all the participants had to request their contribution in order to become part of the study is a benefit. Since the recording of food-intake is a burdensome task, motivated participants tend to be more precise in their recordings compared to participants that are chosen randomly (Willett 1998). Another advantage of this sample is that the participants were very interested in the subject of the study. Most of them stated so and furthermore that they were very interested to be informed about the emissions caused by their individual diet. The resulting food associated GHG emissions might thereby be more precise than with a randomly selected sample.

5.6 Future Studies

Future studies in a similar direction should probably try to involve a larger amount of participants from a greater variety of backgrounds, because the sample in this study is not representative for the average Swedish population in terms of age or education. That way, uncertainties can be reduced and the results will get more reliable. With more participants it might also be possible to have a further subdivision into different meat-free scenarios. The vegetarian sample for example could be divided into ovo-lacto-vegetarian, lacto-vegetarian and ovo-vegetarian. Among the food-groups consumed by the vegans, air-transported products were the only group that had particularly high emissions. Thereby, a division into persons that consume products that were transported by plane on the one side and those that do not consume such products on the other side might be possible in the vegan sample.

Future studies might also want to consider other environmental impacts associated with diets. They might address the question of efficiency, for example water- and land-use or compare the input of different resources (for example phosphor which is used in the production of fertilizer) or the energy-demand in general. Other differences could be the levels of acidification and eutrophication caused by a particular dietary scenario or the depletion of natural resources. Also, to what extend waste and other toxic materials are generated or arable land gets degraded could be inquired.
6. Conclusion
In conclusion, some differences in GHG emissions between the average vegan and the average vegetarian diet could be obtained. It should be noted however, that the difference between an average Swedish diet and the vegetarian diet found in this paper is much greater than the difference between the two meat-free alternatives. This shows that individual dietary choices can – to a certain point – influence the amount of GHG that are released.

However climate change is only one of the impacts that food production has on the environment. And as Weber and Matthews (2008) stated, environmental concerns in return make up only one of the many factors that lead to the choice to consume a particular food. Any attempt to change consumer behaviour should probably be based on and include a variety of such factors in order to be successful.

7. Acknowledgement
I want to thank everybody that was involved in the creation of this study. First of all the participants that took it upon themselves to keep track of everything they ate and drank. They provided the information on which this work is based. I also want to thank my supervisors Helena Pedersen and Fredrik Hedenus for their support and insights. Special thanks to the partner for being there.
8. References


Garnett, T. 2011. Where are the best opportunities for reducing greenhouse gas emissions in the food system (including the food chain)? *Food Policy*, 36, Supplement 1, pp.S23–S32.


Appendix 1 – Information for participants

My name is Andreas Baumann and I study a Master’s program in Sustainable Development at Uppsala University. For my thesis I want to study different vegetarian diet models (namely ovo-lacto-vegetarian and vegan) and the main contributors to greenhouse gas emissions among their particular food sources.

The link between meat – in particular red meat – and greenhouse gas emissions is nowadays established. I want therefore to focus my research on persons that already eliminated meat in their diets. So far studies like these have not been done with real data but with hypothetical diets. That’s why I would like to ask you to write down for one week exactly what you eat and drink.

You can use the attached diet record to note your food intake. However any other form you might prefer works, as long as it contains exact descriptions of your choices and all the parameters of the attached diet record. I will also provide one example-day to illustrate how detailed your descriptions should be.

For me it is easiest if you give all the measurements for the food before cooking it, because otherwise I have to recalculate the original weight. However if you can’t measure the food before cooking (because you are not cooking yourself for example) the weight after cooking is of course also fine. Please mark which way you measured your meal.

For fruits and vegetables where the peel contributes to a large proportion of the weight (for example oranges, bananas or melons) I need to know whether the peel is included in the measurement or not. I hope this doesn’t sound to confusing. But if you have a look at the example it should be much clearer, otherwise please let me know.

Your participation in this Cross-sectional study is completely voluntary. You may refuse to participate in the survey or to withdraw your statement at any point. All the information you provide will be kept completely confidential. No reference will be made in written or oral materials that could link you to the study. In the final report, the information you give me will be combined with what I get from everyone else who participates in the study. Only me and my thesis supervisors will have access to the data, and the data will be used only for the research purposes stated in this letter.

If you have any questions about the study, you may write me at master.thesis.sd@gmail.com or call at +46 730 949 534. You can also contact one of my supervisors Helena Pedersen (helena.pedersen@mah.se; +46 40 665 80 20) or Fredrik Hedenus (hedenus@chalmers.se; +46 31 772 34 53).
### Day 1

<table>
<thead>
<tr>
<th>Food and Drink (describe each item separately; o=organic)</th>
<th>Amount (b=before cooking, a=after cooking)</th>
<th>Measurement (grams, ml, dl, tablespoons etc.)</th>
<th>Pre-cooking state (dried, fresh, frozen, canned etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Breakfast</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breakfast</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rolled oats; o (soy)milk</td>
<td>139 b</td>
<td>gram</td>
<td>dry tetra pack</td>
</tr>
<tr>
<td>1 banana (including peel)</td>
<td>153 b</td>
<td>ml</td>
<td></td>
</tr>
<tr>
<td>orange juice</td>
<td>147 b</td>
<td>gram</td>
<td>fresh tetra pack, concentrate</td>
</tr>
<tr>
<td>200 b</td>
<td></td>
<td>ml</td>
<td></td>
</tr>
<tr>
<td><strong>Snack</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>walnuts (without shell)</td>
<td>30 b</td>
<td>gram</td>
<td>bought without shells</td>
</tr>
<tr>
<td>1 apple; o</td>
<td>132 b</td>
<td>gram</td>
<td></td>
</tr>
<tr>
<td><strong>Lunch</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pasta (100% wheat, o)</td>
<td>107 b</td>
<td>gram</td>
<td>dry</td>
</tr>
<tr>
<td>olive oil (cold pressed)</td>
<td>15 b</td>
<td>bottled</td>
<td></td>
</tr>
<tr>
<td>42 b</td>
<td></td>
<td>gram</td>
<td></td>
</tr>
<tr>
<td>277 b</td>
<td></td>
<td>fresh</td>
<td></td>
</tr>
<tr>
<td>tomato sauce</td>
<td>200 b</td>
<td>tetra pack</td>
<td></td>
</tr>
<tr>
<td>1 onion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 carrots; o</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dinner</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 slices rye bread</td>
<td>120 b</td>
<td>gram</td>
<td></td>
</tr>
<tr>
<td>Precooked chickpeas</td>
<td>150 b</td>
<td>tetra pack</td>
<td></td>
</tr>
<tr>
<td>linseed oil (cold pressed, o)</td>
<td>15 b</td>
<td>bottled</td>
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</tr>
<tr>
<td>apple vinegar; o</td>
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<td></td>
</tr>
<tr>
<td>146 b</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cucumber</td>
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<td></td>
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</tbody>
</table>

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24
Appendix 3 – conversions volume to weight

1 dl soy granulat = 25g
1 dl rice = 100g -> cooked: 2 dl/250g
1 dl flour = 66g
1 dl oats = 55g
1 dl sunflower seeds = 45g
1 dl red lentils = 100g
200g hazelnuts = 3 dl -> 1 dl = 66g
1 table spoon sugar = 12 g
200 ml coffee = 12 g coffee powder
1 slice of bread = 55g

Appendix 4 – average composition of the two diets in this study

**vegan**

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<thead>
<tr>
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<th>% emissions</th>
<th>% energy intake</th>
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<td>9,2</td>
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<tr>
<td>vegetables</td>
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<tr>
<td>cereals</td>
<td>19,2</td>
<td>36,1</td>
</tr>
<tr>
<td>pulses</td>
<td>12,2</td>
<td>14,3</td>
</tr>
<tr>
<td>vegetal fat</td>
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<td>20,1</td>
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<td>luxury food</td>
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<td>11,7</td>
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<tr>
<td>aviated goods</td>
<td>7,1</td>
<td>0,3</td>
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</table>

**vegetarian**

<table>
<thead>
<tr>
<th></th>
<th>% emissions</th>
<th>% energy intake</th>
</tr>
</thead>
<tbody>
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<td>fruits</td>
<td>18,2</td>
<td>8,2</td>
</tr>
<tr>
<td>vegetables</td>
<td>12,4</td>
<td>6,3</td>
</tr>
<tr>
<td>cereals</td>
<td>13,4</td>
<td>33,4</td>
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<td>14,4</td>
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<td>luxury food</td>
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<td>0</td>
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