Climate friendly dietary guidelines

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ABSTRACT

The aim of this study was to investigate how the present Danish diet could be changed in a climate friendly direction that follows the recommendations of a healthy diet. The carbon footprint (CF) of an average Danish diet was calculated and compared to CF of a recommended healthy diet by 1) modifying the average diet according to the Danish food based dietary guidelines, 2) and adjusting to ensure an iso-energy content and a nutrient content according to the Nordic Nutrient Recommendations. Afterwards the healthy diet was changed further to reduce CF.CF from the diet was reduced by 4%, if the healthy diet was eaten instead of the average current diet. However, if the diet was climate optimized by choosing foods with a low CF within the food groups; meat, vegetables and fruit, CF of this diet may be reduced by 23 % compared to CF of the average diet.

Keyword: Danish average diet, carbon footprint, Danish food based dietary guidelines

1. Introduction

In recent years focus has been on emission of greenhouse gases (GHG) from the food production. It has been estimated that the food sector in the developed countries contributes with up to 30 % of total GHG emission (Heller et al 2013; Tukker et al. 2009). Several Climate Summits organized by United Nation (latest COP19 was held in Warsaw, Poland from 11 to 23 November 2013) have been held in order to address the climate change at an international level, which unfortunately didn't result in specific targets or actions (UN 2009; UN 2010).

The special thing about food production is that in addition to contributing to emission of CO_2 from fossil energy consumption it also contributes with the so-called non-energy-related GHG emission – in form of the nitrogen oxide (N_2O) emissions related to use of fertilizers, deforestation (CO_2), and methane (CH_4) from ruminant digestion.

The diet and consequently the related food production contribute to the GHG emission. The different stages of each food items life cycle contribute to the GHG emission: the primary agricultural food production, food processing, as well as during transport and storage of food (Carlsson-Kanyama et al. 2003; Carlsson-Kanyama and Gonzales 2009; Garnett 2008; Garnett 2011; Nielsen et al. 2003). Finally, also the cooking at home contributes to the GHG.

The climate impact can be assessed from different perspectives; a production perspective i.e. the burden of the total food produced in Denmark inclusive emissions from food that is exported to other countries, or alternative from a consumer perspective – i.e. the burden of the food consumed in Denmark exclusive emissions from food that is exported and inclusive emissions from food that is produced outside Denmark. Seen from the production perspective, Denmark's agricultural production was estimated to represent 16 % of the total Danish emission of GHG (Olesen 2008). The climate impact of the Danish food consumption from the consumer perspective was calculated to be around 2.8 tons CO_2-eqv / person/year – equivalent to approximant 15.4 mill. tons CO_2 for the total Danish population and thus approximate 25 % of all GHG from The Danes' total consumption according to IDA's Climate Plan 2050 (Anonymous 2009).

Different types of foods contribute to different degrees to the climate impact. There are big differences between the level of GHG emission from different food groups e.g. between animal products such as meat and cheese and vegetable products such as vegetables, flour and grain. Also within the various food groups there are differences, e.g. between different types of fish or meat depending on the way the products are produced (Carlsson-Kanyama and Gonzales 2009; Olesen 2009).

The amount of GHG emitted by a produced food product is called the food's carbon footprint (CF). CF or global warming is one among several impact categories; acidification, nutrient enrichment, photochemical smog and land use etc. The CF is calculated by a life-cycle assessment (LCA), which includes GHG emission from the foods whole life cycle: agriculture, horticulture or fishing, including emissions related to the production of inputs such as fertilizers, processing, transportation and storage of food products until the food products are

placed on the shelf in the supermarket. The CF of the preparation at households is typical not included (Mogensen et al. 2009a; Garnett 2008) and not needed in some comparison studies (Tukker et al. 2011). Some LCA calculations also include estimations of GHG contribution derived from food waste (Mogensen et al. 2011; Anonymous 2009). Differences in the used LCA calculation methods may complicate comparisons between CF from different sources. Furthermore, production methods and energy resources change over time, and therefore influence the results of calculations.

This study (Thorsen et al. 2012) was based on Danish food based dietary guidelines from 2005 (Astrup et al. 2005) including currently updates. They aim at increasing the intake of fruit and vegetables, bread and cereals (coarse or wholegrain) and fish, and a decrease in intake of fat from dairy and meat products and of sugar containing products. In 2013 the scientific evidence of the Danish food based dietary guidelines was updated. The main conclusions were that the increase of fruit and vegetables was maintained, fish intake was increased, an increased intake of wholegrain cereals was specified and the decrease in fat from dairy and meat products was emphasized. Furthermore the intake of red meat (cow, sheep, pig) and the sugar containing foods were restricted, especially sugar containing beverages.

1.1. Objectives

The aim of this study was to investigate how the present Danish diet could be changed in a climate friendly direction and at the same time following the recommendations of a healthy diet.

2. Methods

The carbon footprint (CF) of the average Danish diet estimated from the National Danish Survey on Diet and Physical Activity from 2003 to 2008, including 3354 adults, 18-75 years of age, hereof 47% men (Pedersen et al. 2010) was estimated. CF of an average diet was compared with CF of a diet that follows the Danish dietary recommendations. This diet was obtained by 1) modifying the average diet by scaling the food groups according to the Danish food based dietary guidelines (Astrup et al. 2005), and 2) adjusting to ensure an iso-energy content of the diets and a nutrient content that follows the Nordic Nutrient Recommendations (Nordic Council of Ministries 2004). The healthy diet was designed by using a modeling tool developed from the Danish nutrient calculating system GIES (Biltoft-Jensen et al 2008).

To assess the impact of food production on global warming the CF from each food item was calculated by use of life cycle assessment (LCA) (ISO 2006a; ISO 2006b). The LCA method implies that all emissions of GHG from cradle to grave are included. I.e. all GHG emissions from production and transportation at the farm, but also the GHG emissions related to processes after the food leave the farm are included. The CF from individual foods i.e. is expressed in CO_2 equivalent per unit of food produced, and the functional unit (FU) is one kg food. The CF values are from Mogensen et al. (2009 b) and are based on data from Nielsen et al. (2003). The average CF for the individual food group is weighted according to the distribution of different types of food items within the food group in both diets.

In the calculation of the CF of food intake the contribution from GHG emissions related to food waste was taken into account from the whole food chain, from production to retail and households. As there is no Danish estimations of food waste in households, waste was estimated from an English report about food waste on individual food groups; on average about 20% of purchased food ends up as edible waste, i.e. waste that could have been avoided (WRAP 2008).

The healthy diet was investigated further with the aim to reduce CF of the diet by using the “hot spot” approach. Hot spot food groups were in focus, i.e. food groups where it is easy and convenient to change between different food products in the group in order to minimize the CF. Hot spot analyzes are interesting because in that way you could help the consumer to choose more climate friendly food, while taking into account also the Nordic recommendations (Nordic Council of Ministries 2004) and the 8 Danish dietary guidelines (Astrup et al. 2005).

When the hot spot perspective is related to the dietary guidelines it is important to focus on food groups that have a high food consumption (large amount of food) and/or include foods having a large CF (high CO_2/kg food). The next step is to assess how foods of the hot spot food groups could be exchanged with similar foods within the group with lower CF.

Finally, the Danish food based dietary guidelines from 2013 (Danish dietary guidelines 2013; Tetens et al. 2013) were investigated and if relevant, complementary advises related to improving the climate impact were added.

3. Results

The estimated CF from the Danish' average diet (2003-2008) and a modeled recommended diet that meets the dietary guidelines and the nutritional recommendations are shown in Table 1.

Table 1 comprises 14 different food groups. Both diets are scaled to an energy intake of 10 MJ/day. These food intakes also give rise to food waste in retail, processing and household. Regarding fruit and vegetables also a 20 % peel waste (inevitable waste) is included. Table 1 shows an estimate of how much the changes from the average diet of the modeled recommended diet would benefit the climate. It is seen that the largest differences obtained by a reduction of the amount of meat with approximate 50 g. This is to some extent cancelled by the contribution from the foods replacing the meat such as the food groups of fruit, vegetables, milk and fish which according to the Danish food based dietary guidelines 2005.

The calculation shows that CF from the diet was reduced by 4%, if the healthy diet was eaten instead of the average current diet. The largest reduction is a result of reduced intake of meat and beverages (beer and wine). The GHG contribution of beverages (excluding milk and juice) has declined by almost 40 %. Overall the recommended diet has a CF that was approximate 4 % lower than the current average diet.

Table 1. The carbon footprint (CF) for an average Danish diet and for a modelled recommended diet (that fulfills both the dietary guidelines and the Nordic recommendations). Both diets are scaled to a daily energy intake of 10 MJ. The CF values are from Mogensen et al. (2009 b) and are based on data from Nielsen et al. 2003.

Food group	CF, kg CO_2/kg food	Intake g/person/day		Food waste, % [6]	CF form the diet gram CO_2/person/day	
		Present average diet	"Modelled recommended diet"		Present average diet	"Modelled recommended diet"
Milk, dairy products	1.2	359	500	3;2;2	462	644
Cheese	11.3	38	25	3;2;2	455	303
Bread, rice, pasta	0.8-3.3	236	274	31;6;2	403	480
Vegetables	0.1 – 2.9	186	304	(19-45);6;2; (0-20)	381	567
Potatoes	0.2	113	192	19;2;2;20	31	52
Fruit (ex. Juice)	0.4	245	271	26;6;2;20	230	260
Juice	1.0	80	50	18;2;2;0	102	63
Meat	3.6 – 19.4 [2]	121 [3]	87 [4]	13;2;2;0	1599 [7]	1277 [7]
Poultry	3.4	27	31	13;2;2;0	149	171
Egg	2,0	19	25	18;2;2;0	49	63
Fish	1.8 – 10,5	25	42	13;2;2;0[8]	170	292
Fats	5.1	38	32	3;2;2;0	219	173
Sugar and candy	1.0	36	23	18;2;2;0	41	29
Beverages	0.02 – 2.1	2273	1955	3;2;2;0	698	417
Total diet [1]					**4986 (100)**	**4790 (96)**
Recommended and climate friendly diet [1,5]						**3864 (77)**

[1] Beverages are included, figures in brackets: percentages related to average diet.

[2] Climate footprint per kilo carcass – Amount of carcass behind an intake is calculated by using a factor 1,47 for beef, 1,33 for pork and 1,38 for poultry (chicken)

[3] Type of meat in the present average diet: Men: 135 g meat/day: 25 % beef, 75 % pork. Women: 106 g meat/day: 28 % beef 72 % pork.

[4] Meat in the recommended diet: Men: 92 g meat/day: 30 % beef, 70 % pork. Women: 81 g meat/day: 33 % beef, 67 % pork.

[5]) Climate friendly diet: The only difference from "recommended" diet is: within the food group: fruit, vegetables and meat a climate-friendly solution is chosen e.g. For the food group vegetables carrot is chosen, for the food group fruit apple is chosen and for the food group meat the reduction is done for beef and then for pork.

[6] A larger food production is needed than the food intake figures show since food waste is found in all parts of the food chain. The figures cover edible food waste in household ; retail; processing; and peel/skin (not edible, inevitable waste for fruit, vegetables and potatoes).

[7] Incl. calculation from carcass to meat.

[8] All fish products are calculated without bone like fillet and peeled shrimp

In Table 2 we take a closer look at the CF for the hot spot food groups: meat, vegetables, fruit and fish. From Table 2 it can be seen that it is possible within the different food groups to reduce the contribution to CF by choosing foods with a lower CF. In order to choose climate friendly foods it is better to choose e.g. poultry or pork instead of beef, and fruit or vegetables in season instead of food produced in a greenhouse or imported. Regarding fish a climate friendly choice would be herring or mussels instead of flatfish or shrimps.

In addition the diet was optimized to reduce CF of the diet by choosing foods with a low CF within the food groups; meat, vegetables and fruit, CF of this diet may be reduced by 23 % compared to CF of the average diet.

Table 2: Effect on the contribution to carbon footprint (CF) from different food groups dependent on choice of food item within food group

Food group	**Foods item**	**"Modeled" recommended daily intake in gram[2)]**	**Food waste % [5)]**	**CF from the food items kg CO_2/kg food**	**Contribution to CF from the production of the daily intake of food [1)], gram CO_2/day**
Meat and meat products	Average diet – mix of food items within the food group	87	13;2;2;0	9.2 [4)]	1277[6)]
	Beef	87	13;2;2;0	19.4 [3)]	2966 [6)]
	Pork	87	13;2;2;0	3.6 [3)]	498 [6)]
	Chicken, fresh	87	13;2;2;0	3.1 [3)]	445 [6)]
	Chicken, frozen	87	13;2;2;0	3.7 [3)]	531 [6)]
Vegetables (ex. potatoes)	Average diet – mix of food items within the food group	304	(19-45);6;2;(0-20)	1.32 [4)]	567
	Carrot	304	19;6;2;20	0.122	62
	Onion	304	19;6;2;20	0.382	195
	Greenhouse vegetables	304	19;6;2;0	2.7	1099
Fruit	Average diet – mix of food items within the food group	271	26;6;2;(0-20)	0.52 [4)]	260
	Orange	271	26;6;2;20	0.7	347
	Banana	271	26;6;2;20	0.5	248
	Nuts, almonds	271	26;6;2;0	0.88	350
	Danish apple, pear	271	26;6;2;20	0.1	50
	Imported apple, pear	271	26;6;2;20	0.4	198
Fish and fish products [7)]	Average diet – mix of food items within the food group	42	13;2;2;0	5.7 [4)]	292
	Herring, fillet, peeled, frozen	42	13;2;2;0	1,8	90
	Shrimp, frozen, peeled	42	13;2;2;0	10,5	528
	Codfish, fillet, frozen	42	13;2;2;0	3,2	161
	Flatfish, fillet, frozen	42	13;2;2;0	7,8	392

[1)] Calculation of CF is based on produced amount of feed, taking into account food waste.
[2)] Food intake is an average for men and women.
[3)] CF of meat is given as CF per kg carcass, needed amount of carcass per kg meat intake: 1.47 for beef 1.33 for pork and 1.38 for poultry.
[4)] Average CF for all type of meat in the meet group, weighted according to distribution of different types of meat, accordingly average CF for the other food groups
[5)] Food waste in household; retail; processing; and peel/skin (not edible, inevitable waste for fruit, vegetables and potatoes)..
[6)] Incl. calculation from carcass to meat.
[7)] All fish products are calculated without bone like fillet and peeled shrimp

In the climate friendly diet, we have reduced the meat intake by 50 g/day, removed the beef and then reduced the pork. The intake of vegetables was increased with 300 g/day, and the vegetables with the lowest CF (such as carrots) was chosen, and regarding fruit the amount of fruit was increased by 50 g/day and fruit with the lowest CF (such as Danish apple) was chosen. The results are shown in Table 1 above and in footnote 5.

4. Discussion

The present study showed that the climate impacts from human food consumption can be reduced by conscious food choices. Beside that minimizing food waste and choosing a more sustainable food production in relation to agriculture could reduce CF from food production further.

In this study, the most recent dietary data were used for rough calculations of the climate contribution of a recommended diet compared to the current Danish diet. According to our calculation the climate contribution from the diet will be 4 % reduced, if the recommended diet is eaten instead of the average current diet. A saving in carbon footprint in the order of 4% CO_2-eq is so small compared to the uncertainty of the data included that is not necessarily a real saving.

In addition to eating a recommended diet people would optimize their diet in a more climate friendly way by choosing foods with a low carbon footprint, especially in the food groups; meat, vegetables and fruit. Our calculations show that the CF of such a climate friendly diet including beverages would be reduced by 23 % compared to CF contribution of the average diet. Thus, a climate optimized recommended diet would provide a significant reduction of the CF (23%) as compared to a recommended diet (4%). The number (23 %) is not essential, it can be less or more, but the savings are significant compared to the recommended diet. In real life the savings from the food groups meat, fruit and vegetables probably would be less than estimated here, but on the other hand optimized choices within the other food groups is expected to provide further savings. Thus there is a great potential for reducing CF of the diet by choosing climate friendly within a recommended diet. If households further reduce their food waste, it will have a major effect on climate impacts. The total food waste in households is estimated to be around 20%, accounting for 12.5% of the CF of food production. However, the calculations are based on English data from investigating food waste in households (WRAP 2008). More recent data from Danish households are needed to validate this part of the calculation.

Other studies (Mogensen et al. 2009b; Saxe et al. 2006; Tukker et al. 2011) find similar to the present study that a diet following the dietary guidelines will have a slightly lesser impact on the climate all other things being equal. However, it has also been found that high-nutritional diets had significantly higher GHG emissions than low nutritional quality diets (Vieux et al. 2013), Another study found that the GHG emission was 27 % lower when the diet (the New Nordic) was climate optimized by choosing either less beef or by substituting all meat with legumes, dairy products and eggs (Saxe et al. 2013).

In this study the energy and nutrient content are estimated for the average as well as the recommended diet. The diets are comparable since the energy content equals, and the recommended diet is also adjusted so that the nutrient contents are in accordance to the recommended levels. (Vitamin D is an exception, so other sources should be taken into account, such as supplementation and/or production within the body exposing the skin to sunlight). Therefore the functional unit kgCO_2/kg food of CF is used for the foods and g CO_2/day for the diets. However, the present study is an approximation with regard to the CF calculations and is conducted to get an overview of the CF from the overall diet. More accurate calculations of the climate-optimized diet require more in-depth investigations and further nutritional calculations that are beyond the aim of this study. For instance in the climate-friendly diet the milk intake is set to be 500 g/day, although this could be reduced to 250 ml/day in accordance with the Danish dietary guidelines from 2013 (Tetens et al. 2013), it might not be in accordance with removing all of the beef. Furthermore, a decrease in milk content of the diet needs to be accompanied by an increase in other food items that will provide energy and nutrients in approximately the same amount.

Fruits, vegetables, cereals and potatoes, which according to the dietary guidelines should be by far the largest part of the diet, are all low in climate impact, especially when choosing open field grown products and avoiding products transported by airplane. Meat and cheese are generally high in CF, but CF from meat as beef and lamb is higher in CF than pork and poultry. Also vegetable oil should replace butter and hard margarines, vegetable oils generally have a lower CF. Stimulants as sweet and alcoholic drinks, sweets and cakes, which should decrease in the Danish diet, probably have a rather high CF, but the data concerning CF of this food group is weak and should be improved considerably. An increased intake of fish that is advised by the dietary guidelines would by all means increase the climate impact and might be problematic if leading to overfishing (Clonan et al. 2013), but the negative impact may be limited by a conscious choice of fish products. Eating the recommended diet would change the diet in the direction of lower fat and higher fiber content, e.g. by reducing the intake of red meat and cheese and instead eat more coarse vegetables and fruit, bread and grains. By further choosing foods with a low carbon footprint whenever possible the climate impacts of the food consumption is reduced significantly. The climate friendly additions to the dietary guidelines should be short advises that are easy to understand and follow by the consumer. Therefore advises regarding the transportation of the foods are not included, since it is very complicated to explain the exceptions and since the consumer usually has no knowledge about how and how far the food items have be transported. These qualitative advices was in line with

guideline development in Sweden and the Netherlands (Fogelberg 2008; Health Council of the Netherlands 2011).

5. Conclusion

It was concluded that there is potential synergy between a healthier diet and a more climate friendly diet. There seems evidence to complement the Danish dietary guidelines 2013 with the following advice *(in italic type)* to reduce the CF from the diet:

- Eat a varied diet, not too much, and be physical active
- Eat fruit and many vegetables – *preferably open field and in season*
- Eat more fish - *choose the climate friendly fish; herring and mussels*
- Choose whole grain
- Choose low-fat meat and meat products – *choose pork and poultry rather than beef and lamb*
- Choose low-fat milk and milk products - *restrict intake of cheese*
- Eat less saturated fat - *choose vegetable oils rather than animal fat*
- Eat foods with less salt
- Eat less sugar - from soft drinks, sweets and cakes
- Drink water - rather than sweet and alcoholic drinks
- Avoid overeating - *and waste - will also reduce CF from food production since less food need to be produced*

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