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Relative GHG footprint of two healthy Nordic diets

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ABSTRACT

Using LCA we analyzed the GHG footprint of two healthy Nordic diets: One based on the Nordic Nutritional Recommendations (NNR) and the other on preliminary specifications for a New Nordic Diet (NND) as part of the OPUS project. Both diets were analyzed with the average Danish diet (ADD) as reference, and all diets were adjusted to similar energy and protein contents. The healthy diets were constructed by modifying ADD in three ways. By modifying the relative content of foods and beverages NNR emitted 8 % less GHGs than ADD, and NND 7 % less. By including transport associated with import, NND, which consisted of local produce only, emitted a further 5 % less GHGs than ADD, totaling a 12 % reduction. By including an organic share of 80 % in NND and the actual shares in ADD and NNR, NND emitted more GHGs, now only 5 % less than ADD.

Keywords: GHG (greenhouse gases), GWP (global warming potential), NND (New Nordic Diet), NNR (Nordic Nutritional Recommendations), OPUS

1. Introduction

This study is part of the OPUS project: '*Optimal well-being, development and health for Danish children through a healthy New Nordic Diet* '. The aim of OPUS is to introduce a science-based New Nordic Diet (NND) to the Nordic public through a large number of recipes developed by the some of the foremost Nordic chefs. NND aims at being simultaneously palatable, healthy and environmentally sustainable. NND will be tested in two large-scale intervention studies with multiple response analyses of several hundred adults and children.

In this study we test the GWP of two healthy diets relative to the average Danish diet (ADD) using their GHG emissions calculated by Life Cycle Analyses; NNR defined by the Nordic Nutrition Recommendations (Norden, 2004), and NND defined by preliminary recommendations in the OPUS project. Values for GHG emissions caused by organic and/or conventional foods and beverages were taken from the LCA-Food database (2004) using Stepwise method in SimaPro®, Halberg et al. (2006), Williams et al. (2006), Audsley (2009), Halberg et al. (2010) and by consensus among the authors based on more recent sources.

GHGs are only one of several environmental indices used in evaluating environmental effects of goods and services. We are well aware that it does not give a complete picture of environmental responses to food choices, but data for GHG are presently the most available environmental indicator. More environmental indices will be applied in future studies.

2. Methods and materials

The composition of ADD and NNR were described by the Danish National Food Institute and 2.-0 LCA consultants based on data from national questionnaires on food intake and data for food production and import from Statistics Denmark (Saxe et al, 2006). The environmental effects of foods and beverages are a result of what is produced, not of what is consumed.

The NND is defined by three core elements: (a) changes in diet composition, (b) local products preferred to imported products, and (c) organic products preferred to conventional.

The preliminary specifications for NND changes the contents of food and beverage relative to ADD as follows: 1.5X ADD fruit, 18.8X ADD berries, 3X ADD cabbage, 5X ADD roots, 1.5X ADD potatoes, 4.3X ADD legumes, 1.4X ADD other vegetables, 2.1X ADD whole grain products, 7X ADD nuts, 2.3X ADD seafood, 0.7X ADD meet, 1.4X ADD dairy products, 0.7X ADD cheese, 1.5X ADD eggs, 0.5X ADD beer, butter, candy, cake, convenience, ice cream, sugar; No rice, industrial pasta, wheat bread, chocolate, tea, coffee and cocoa. Healthy pasta, marmalade, and juice are produced by local suppliers based on the extra amount of fruit and vegetables included in NND. Wine and alcohol is substituted by beer.

Table 1. Diet composition and emission of greenhouse gases. The first three columns give the weight of the main foods and beverages in the three diets of this study; ADD, the Average Danish Diet; NNR, A diet according to the Nordic Nutritional Recommendations; and NND, The New Nordic Diet. The following 3 sets of 3 columns give the potential GHG emissions compared of the three diets. NND contains only Danish produce and it is 80 % organic by weight.

Products	**Diet composition**			**Emission of greenhouse Gases, GHG, kg/person/year**								
	kg/person/year			Composition implemented			Local purchase implemented			Organics implemented		
	ADD	NNR	NND	ADD	NNR	NND	ADD	NNR	NND	ADD	NNR	NND
Beer, wine, alcohol	114.5	45.9	57.2	154.2	62.0	52.8	176.7	71.1	52.8	176.7	71.1	52.3
Berries	3.5	6.4	65.1	2.4	4.4	44.6	2.8	5.3	44.6	2.8	5.3	44.6
Butter	2.6	0.5	1.3	16.7	3.1	8.3	16.9	3.2	8.3	16.6	3.1	7.5
Cabbage	6.1	11.6	18.3	1.4	2.6	4.1	2.5	4.7	4.1	2.5	4.7	4.1
Candy	20.3	11.1	10.1	123.6	67.8	61.8	141.8	87.8	61.8	141.8	87.8	61.8
Cheese	13.4	15.2	21.9	154.0	174.0	250.9	154.5	174.4	250.9	154.4	174.3	248.4
Coffee+tea+cocoa: dry	15.7	8	7.9	118.8	60.1	6.8	118.8	60.1	6.8	118.8	60.1	6.8
Convenience	5.2	4.6	2.6	4.0	3.5	2.0	4.6	4.0	2.0	4.6	4.0	2.0
Dairy products	138.3	166.8	197.5	166.5	205.8	237.8	167.0	205.8	237.8	161.7	198.7	214.0
Eggs	8	19.8	23.8	16.0	39.5	47.4	16.1	39.8	47.4	17.3	42.7	60.1
Fruit. excl. berries	85.6	149.7	248.8	46.0	81.5	82.8	68.9	122.1	82.8	69.6	123.3	116.9
Herbs	1.8	1.7	5.2	1.6	1.5	14.1	1.9	1.9	14.1	1.9	1.9	14.1
Juice	45.5	24.9	22.8	45.5	24.9	22.8	50.7	27.7	22.8	51.7	28.2	27.7
Legumes	3.6	5.5	15.2	1.7	2.5	7.5	2.3	3.5	7.5	2.3	3.5	7.5
Marmalades	3.8	6.1	0.1	2.0	3.0	0.1	3.5	5.4	0.1	3.4	5.4	0.1
Meat, industrial	74.9	61.6	52	738.7	562.6	509.9	742.6	565.6	509.4	742.8	565.9	546.5
Meat, game	0	0	1.5	0.0	0.0	4.5	0.0	0.0	4.5	0.0	0.0	4.5
Mushrooms +lettuce	7.8	12	6	8.8	13.6	6.9	10.2	15.7	6.9	10.2	15.7	6.9
Mushrooms. wild	0	0	1.8	0.0	0.0	1.8	0.0	0.0	1.8	0.0	0.0	1.8
Nuts	1.6	1.4	11	0.8	0.7	4.7	2.0	1.8	4.7	2.0	1.8	4.7
Oils excl. rape	11.7	16.4	0	29.1	52.6	0.0	29.4	55.7	0.0	29.4	55.6	0.0
Oils of rape	0	0	11.7	0.1	0.0	41.4	0.1	0.0	41.4	0.1	0.0	35.2
Pasta, industrial	6.2	5.9	0	5.6	5.3	0.0	7.1	7.2	0.0	6.8	7.0	0.0
Potatoes	58	94.3	87	12.3	19.8	18.5	15.6	24.9	18.5	15.5	24.7	17.3
Roots, excl. potatoes	19.7	31.1	98.6	3.7	5.8	18.3	7.3	11.5	18.3	7.6	11.8	22.9
Rice	3	4.7	0	10.4	16.5	0.0	11.8	18.7	0.0	11.8	18.7	0.0
Seafood and fish	11.2	21.2	25.1	35.6	67.6	81.7	38.1	72.3	81.7	38.1	72.3	81.7
Softdrinks	118.6	30.9	0	16.6	4.3	0.0	19.3	5.3	0.0	19.3	5.3	0.0
Sugar	4.9	3.4	2.5	4.8	3.3	2.4	4.8	3.3	2.4	4.8	3.3	2.4
Vegetables, others	45.5	61.8	61.5	135.7	193.8	183.7	142.9	202.5	183.7	148.1	209.1	236.8
Wheat, proc. products	39	35.4	0	33.0	29.3	0.0	33.6	29.7	0.0	33.3	29.7	0.0
Whole grain products	39.2	66.3	84	30.5	50.7	65.3	35.3	61.6	65.3	34.9	61.3	60.4
Other products	1.5	0.1	3.3	1.8	0.5	3.4	1.8	0.5	3.4	1.8	0.5	3.4
Sum kg/person/year	911	924	1144	1922	1763	1786	2031	1893	1786	2033	1897	1892
Energy, MJ/person/day	13.21	13.25	13.18	-	-	-	-	-	-	-	-	-
Protein g/person/day	137.2	137.0	137.5									

The DANKOST3000® software was used to calculate the overall energy and protein content in the three diets. With the above specifications for NNR and NND they were a little short in energy and protein relative to ADD. By adding 6 kg of both cheese and eggs per year to NNR and 12 kg of both cheese and eggs and 120 kg apples (for 0.25 l juice a day) to NND, both of the healthy diets had energy and protein contents similar to ADD (Table 1, Fig. 1). We find this to be a reasonable foundation for comparison of diets: simultaneously satisfying hunger and protein demand. Protein is particularly important for elderly people.

3. Results

The total weight of NNR and NND were respectively 1 % and 26 % larger than ADD (Fig. 1). Not counting drinking water, the main contributors by weight are dairy products, beverages, fruit, meat, potatoes, and vegetables. The larger weight of NDD was mainly due to increased contents of fruit, roots and legumes with their high content of water and fiber.

The indicated food and beverage categories are used in the OPUS design, but in our calculations we have used approximately 350 individual foods and beverages.

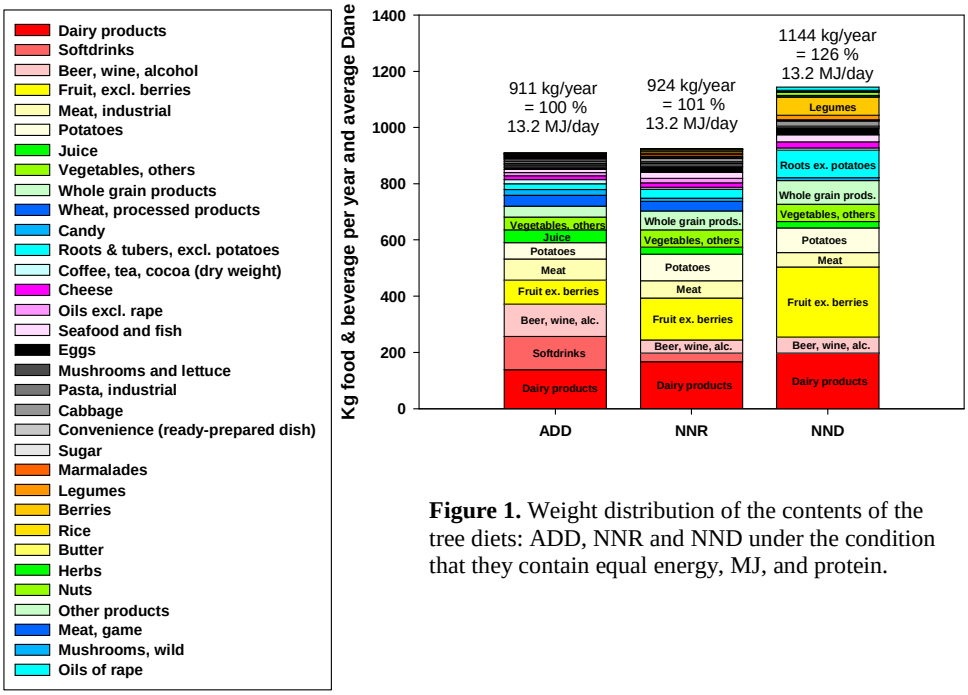

Figure 1. Weight distribution of the contents of the tree diets: ADD, NNR and NND under the condition that they contain equal energy, MJ, and protein.

3.1. Contribution to GHG-emissions by changes in diet compositions

The first level of calculations of effects by diet choices on GWP include changes in content of different food and beverage categories consumed in NNR and NND relative to ADD (Table 1, Fig. 2). At this stage we neither include emissions caused by transport associated with import, nor do we include effects of organic vs. conventional products. Under these conditions, the NNR diet is 8 % better for the environment – measured as GHG emissions – and the NND is only 7 % better (Fig. 2).

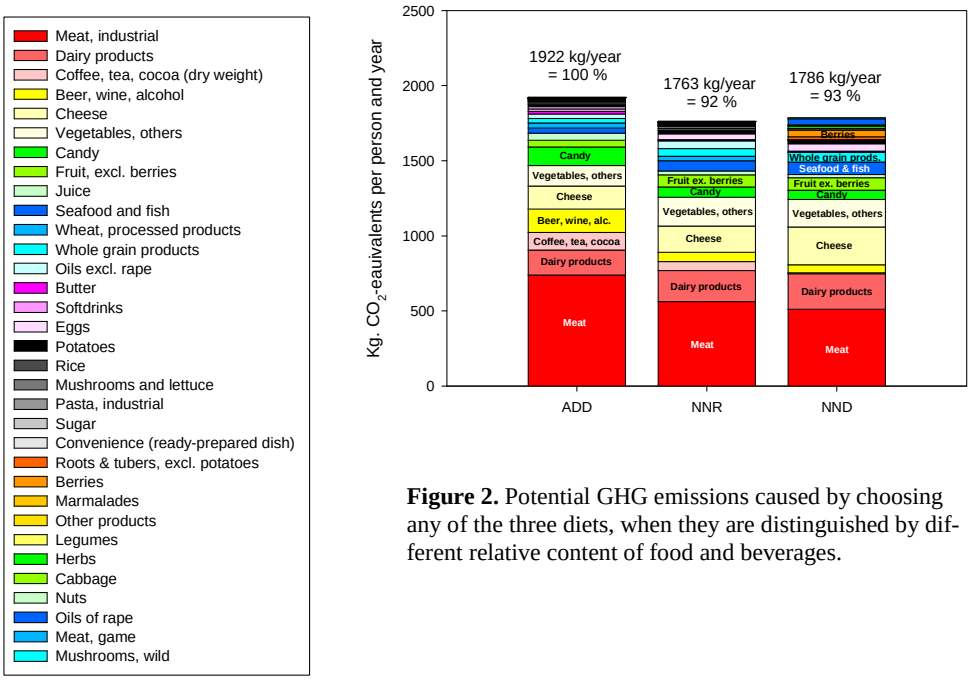

Figure 2. Potential GHG emissions caused by choosing any of the three diets, when they are distinguished by different relative content of food and beverages.

3.2. Contribution by including local produce

The second level of calculations of effects on GWP by diet choices includes means of transport (truck, ship, plane), transport distance (http://www.viamichelin.com), and cooling/freezing en route simulated by data from Ecoinvent for a small diesel generator. For ADD and NNR we used the actual ratio of imported foods, while for NND there were no imports. It is assumed that production efficiency is similar in Denmark and abroad. The benefits of NND measured as GHG emissions are improved from 7 % to 12 % relative to ADD (Fig. 3).

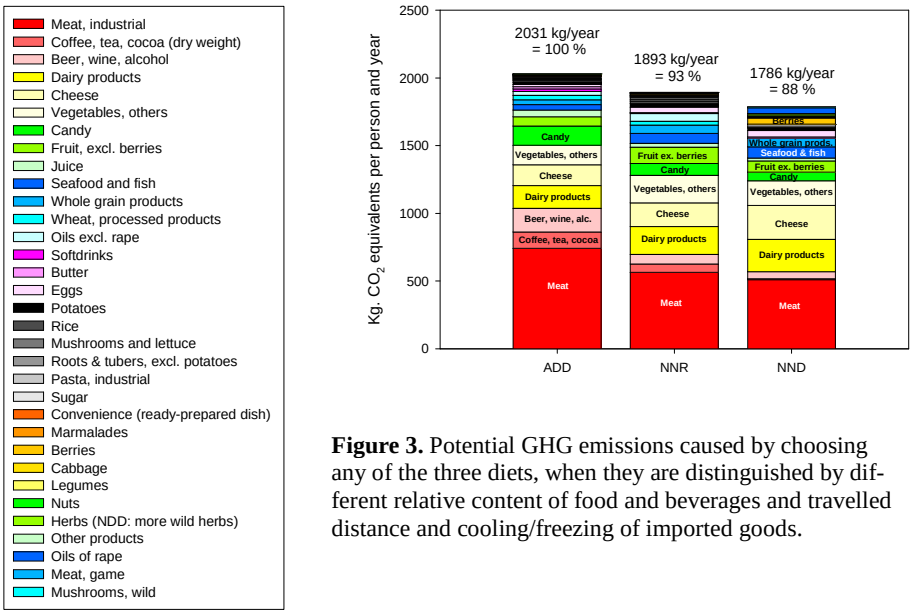

Figure 3. Potential GHG emissions caused by choosing any of the three diets, when they are distinguished by different relative content of food and beverages and travelled distance and cooling/freezing of imported goods.

3.3. Contribution by including organic products

At the third stage of calculations we added/subtracted GHG emissions associated with substituting conventional products with organic products at 2009 ratios for ADD and NNR to an overall ratio of 6.6 % organics (Økologisk Landsforening, 2009). For the NND diet we included all the organics we had data for, to an overall ratio of 80 % organics. 23 organic products were included in the calculations, seven 'negative' (apples, beef, carrots, chicken, eggs, non-alcoholic beverages, tomatoes) *increased* GHG emissions, and 15 'positive' (beer, butter, cheese, coffee, lamb, milk, pasta, rape oil, pork, potato, rolled oats, rye bread, wheat flour and bread, and yoghurt) *decreased* GHG emissions. For NND 382 kg/person/year of 'negative' organics increased GHG emissions by 159 kg/person/year, while 588 kg decreased GHGs by a total of 53 kg GHGs. Thus, the net effect by including organics in NDD was negative by 106 kg GHGs person and year (Fig. 3 and Fig. 4).

However, other effects of organics are positive, e.g. protection of soil structure, omission of pesticides, and better animal welfare. This support inclusion of organics in future diets.

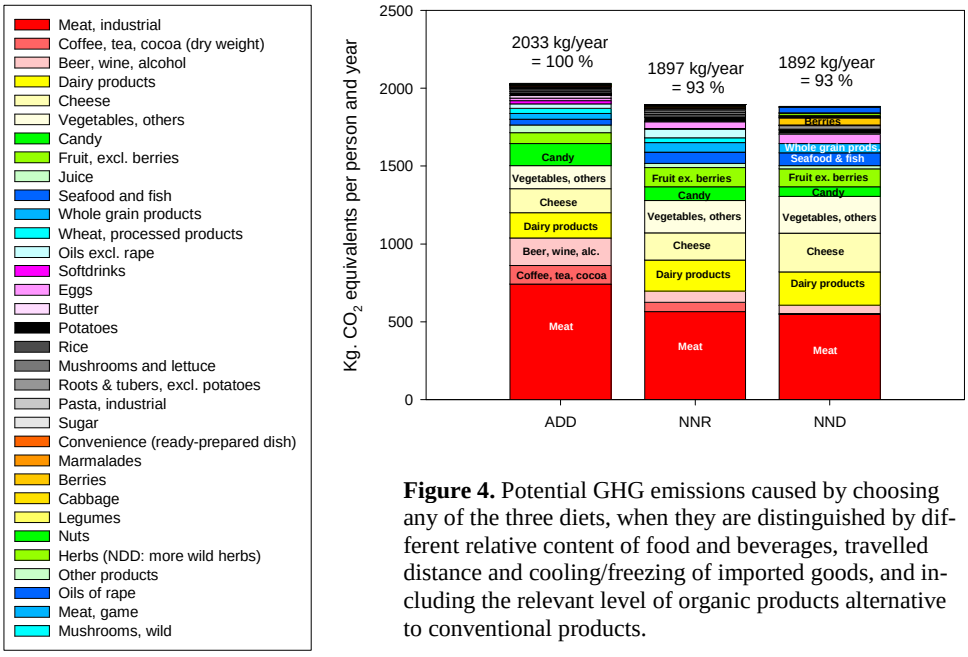

Figure 4. Potential GHG emissions caused by choosing any of the three diets, when they are distinguished by different relative content of food and beverages, travelled distance and cooling/freezing of imported goods, and including the relevant level of organic products alternative to conventional products.

4. Discussion

We have used the best available data for the potential GHG emissions of all foods. This means that the Danish LCA-Food database was updated for items like dairy products and more. Uncertainties include aggregation uncertainty, geographical uncertainty and emission uncertainty. We have estimated the coefficients of variation for emissions, and for most food categories these were smaller than the differences between the emissions of the total diets. This gives us confidence that the observed differences between the diets are significant.

In the final analysis, choosing either NNR or NND are significantly better for the GWP than choosing ADD (Fig. 4). The alternative diets mainly gain their advantage over ADD for two reasons: (1) the 30 % decrease in meat, and (2) the 50 % decrease in beer, sweets and candy. Furthermore, to make NND fully Nordic, imported fruits and nuts were substituted with Nordic fruits and nuts; wine and alcohol were substituted by beer; tea, coffee and cocoa by herb tea; and chocolate by ice cream. All these substitutions improved NND's GWP. Excluding imports in NND was as beneficial to GWP as including 80 % organics was harmful.

To construct climate-friendly diets reductions of wine, beer, coffee, sweets and candy was as efficient as reductions in meet. A study undertaken after the submission of this paper showed that substituting beef with more pork and chicken is an alternative way of reducing climate effects, which is potentially as efficient as choosing a healthy, meatless diet. But it is uncertain which strategy is the easiest to put into practice.

The GHG savings by diet choice may seem small. But the potential for reduction in GWP by switching from ADD to NNR (136 kg GHG saving per year and person) or NND (141 kg GHG) are comparable to other realistic means of environmental protection available to individual citizens, e.g. a 10 % savings on heating of individual homes (130 kg GHG saving). In this perspective the environmental protection by choosing NNR or NND rather than ADD is quite significant. Additional benefits of the alternative diets are improved health, and possibly a lower overall price (Saxe et al., 2006) – depending on the surcharge for organics.

5. Acknowledgements

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6. References

Audsley E. (2009): How low can we go? An assessment of greenhouse gas emissions from the UK food system end and the scope to reduce them by 2050. Cranfield University, UK. http://assets.wwf.org.uk/downloads/how_low_can_we_go.pdf.

Halberg N., Dalgaard. R., Rasmussen M.D. (2006): Miljøvurdering af konventionel og økologisk avl af grøntsager. Danish Environmental Protection Agency. Working Report No. 5. http://www2.mst.dk/udgiv/publikationer/2006/87-7614-960-9/pdf/87-7614-961-7.pdf.

Halberg N., Hermansen J.E., Kristensen I.S., Eriksen. J., Tvedegaard N., Petersen B.M. (2010): Impact of organic pig production systems on CO_2 emission. C sequestration and nitrate pollution. Agronomy for Sustainable Development. http://www.agronomy-journal.org/index.php?option=article&access=doi&doi=10.1051/agro/2010006.

LCA-Food database. (2004): http://www.lcafood.dk/ (accessed through SimaPro).

Norden. (2004): Nordic Nutritional Recommendations. http://www.norden.org/da/publikationer/publikationer/2004-013/.

Saxe H., Jensen R.B., Petersen M.L. (2006): Fødevarers Miljøeffekter. Det politiske ansvar og det personlige valg. Institute of Environmental Assessment. English abstract. http://www.imv.dk/files/ Filer/IMV/Publikationer/Rapporter/2006/fdevare.pdf.

Williams A.G., Audsley. E., and Sandars D.L. (2006): Determining the environmental burdens and resource use in the production of agricultural and horticultural commodities. Main Report. Defra Research Project ISO 205. Bedford: Cranfield University. www.silsoe.cranfield.ac.uk.

Økologisk Landsforening. (2009): Økologisk markedsnotat. http://www.okologi.dk/media/229957/markedsnotat2009.pdf.