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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.

## 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 some of the foremost Nordic chefs. NND aims at being simultaneously palatable, healthy and environmentally sustainable. NND will include 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 is defined by the Nordic Nutritional Recommendations (Norden, 2004), and NND 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 the Stepwise method in SimaPro<sup>®</sup>, 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 i/o statistics from Statistical bureaux (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 meat, 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.

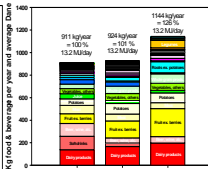
The DANKOST3000<sup>®</sup> software was used to calculate the overall energy and protein content in the three diets. With the above specifications for NNR and NND they were a little short in energy and protein relative to ADD. By adding 6 kg of both cheese and eggs per year to NNR and 12 kg of both 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 physically active and 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 NND was mainly due to increased contents of fruit, roots and legumes with their high content of water and fiber.

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

Products	Diet composition kg person/year	Emission of greenhouse gases, GHG, kg person/year		
		Competition emissions	Local produce emissions	Organics emissions
Beer, wine, alcohol	1047	1047	1047	1047
Berries	12	12	12	12
Cabbage	251	154	154	154
Candy	104	104	104	104
Cheese	104	104	104	104
Coffee, tea, cocoa (dry weight)	104	104	104	104
Convenience	104	104	104	104
Dairy products	1047	1047	1047	1047
Eggs	104	104	104	104
Fruit, incl. berries	1047	1047	1047	1047
Grain	104	104	104	104
Ice cream	104	104	104	104
Legumes	104	104	104	104
Marmalade	104	104	104	104
Meat, industrial	104	104	104	104
Meat, organic	104	104	104	104
Milk, industrial	104	104	104	104
Milk, organic	104	104	104	104
Mushrooms, wild	104	104	104	104
Nuts	104	104	104	104
Other products	104	104	104	104
Pasta, industrial	104	104	104	104
Pasta, organic	104	104	104	104
Potatoes, wild	104	104	104	104
Rice	104	104	104	104
Seafood and fish	104	104	104	104
Sugar	104	104	104	104
Vegetables, others	104	104	104	104
Wheat, incl. products	104	104	104	104
Whole grain products	104	104	104	104
Sum kg person/year	1047	1047	1047	1047
Protein, g person/day	1047	1047	1047	1047

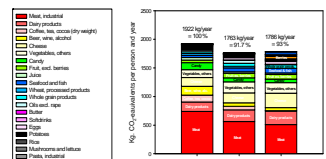


**Figure 1. Weight distribution of the contents of the three diets: ADD, NNR and NND under the condition that they contain equal energy, MJ, and protein.**

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.

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

The first level of calculations of effects by diet choices on GWP includes 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).

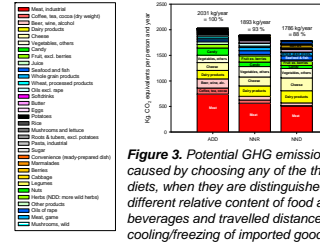


**Figure 2. Potential GHG emissions caused by choosing any of the three diets, when they are distinguished by different relative content of food and beverage.**

### 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

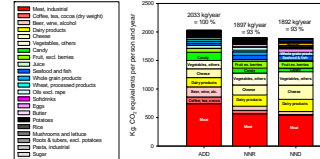
(<http://www.viamichelin.com>), and cooling and freezing en route simulated by data from Ecoinvo for a small diesel generator. For ADD and NNR we used the actual ratio of imported foods, while for NND there were no imports. It is assumed that production efficiency is similar in Denmark and abroad. The 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 organics

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 yogurt) decreased GHG emissions. For NND 382 kg/person/year of 'negative' organics increased GHG emissions by 159 kg/person/year, while 588 kg of 'positive' organics decreased GHGs by a total of 53 kg GHGs. Thus, the net effect by including organics in NND was negative by 106 kg GHGs person and year (Fig. 4).



**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.**

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.

## 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 (2004) 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 30-40 % 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 meat. 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.

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