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The effect of nutritional quality on comparing environmental impacts of human diets

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ABSTRACT

Several studies support the general conclusion that plant-based diets have a lower environmental impact than animal-based diets. These studies, however, do not account for the nutritional quality of diets. The main objective of our study, therefore, was to explore if accounting for nutritional quality affects the comparison of the environmental impacts of human diets varying in their percentage of animal-source food products (ASFP). We also explored whether meals or daily diets are equally suitable to compare environmental impacts of diets. Fifty peer-reviewed studies were found that examined the environmental impact of diets, generally using life cycle assessment (LCA). Only 12 of these studies were reviewed, based on five criteria: study contains more than one scenario; diet scenarios vary in their percentage of ASFP; the weight of each food product was provided; the study assessed global warming potential and/or land use; diet scenarios are not designed for specific (health) groups. For each diet described in the reviewed studies, we quantified the daily intake of nine qualifying and three disqualifying nutrients. Global warming potential and land use, as provided by the reviewed studies, were expressed in four ways: per day, per daily protein intake capped to the recommended intake level of 57 g; per daily protein intake uncapped; and per NRD9.3 (i.e. a composite nutrient score of a diet).

We concluded that the nutrient intake resulting from a meal cannot be used to assess the nutritional quality of a daily diet and, hence, the environmental impact of meals cannot be compared to that of daily diets. Studies on meals were therefore excluded from further analysis. Our results further show that daily diets that had higher percentages of ASFP were associated with higher (excess) intakes of total protein and lower values of NRD9.3. Diets that had higher percentages of ASFP were associated with higher GWPs and LU's per gram protein capped and per unit NRD9.3. Without capping protein to the recommended intake level, GWP and LU per gram of protein were generally lower for diets that had higher percentages of ASFP. Without capping, diets with higher percentages of ASFP are credited for overconsumption of protein. Since overconsumption of protein does not benefit health, we recommend capping to the recommended intake level. The effect of using NRD9.3 rather than day as functional unit was small for GWP. For LU we found no effect. When using NRD9.3 as functional unit, it must be considered that this functional unit requires more data than day or protein. Our analysis is based on a limited number of studies. Although initially a substantial number of studies were found, many of these were excluded because insufficient data were provided about diet composition, only one diet scenario was assessed, or because the studies assessed the environmental impact of meals rather than of diets. We found mainly Western-oriented diets, often designed by the researchers and not representative for actual consumption. For further research on the environmental impact of diets, we therefore recommend analysis on representative daily diets.

1. Introduction

Compared to plant-source food products, production and consumption of animal-source food products (ASFP) is generally associated with a high environmental impact (Cordell et al., 2009;

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Steinfeld et al., 2006). ASFP can provide, however, high-quality protein and are rich sources of micronutrients (FAO, 2009). A moderate intake of ASFP, therefore, can improve the nutritional adequacy of the poor (FAO, 2009).

Several studies have assessed the environmental impact of human diets that varied in percentage of ASFP (Carlsson-Kanyama and Gonzalez, 2009; Davis et al., 2010; Saxe et al., 2012). Most of these studies used life cycle assessment (LCA) to compare the impacts of two or more diet scenarios. LCA is a holistic method to assess the environmental impact (i.e. emission of pollutants and use of resources) of a product during the entire production chain (Guinée et al., 2002). These studies support the general conclusion that plant-based diets have a lower environmental impact than animal-based diets.

To compare LCA results of different diet scenarios, the results should be expressed on basis of a so-called functional unit (FU) (De Vries and De Boer, 2010). An FU represents the primary function of a system. Beside its social and psychological functions, a main function of food production is to satisfy the human body's need for energy and nutrients, such as protein, iron, fibre, vitamins and minerals. Studies that compared the environmental impact of food production focussed on its nutritional function, and, therefore, generally used 'meal' or 'daily diet' as FU. Meals and daily diets within studies were often comparable in terms of energy, protein and fat content. Studies that used a meal or daily diet as FU, however, did not account for the overall nutritional quality of a diet. Accounting for nutritional quality was done by Smedman et al. (2010). They compared greenhouse gas emissions relative to the so-called nutrient density score (NDS) of beverages. NDS is based on individual nutrient scores. The latter express the nutrient contents of food relative to the nutrient requirements (Hansen, 1973). By summing the individual nutrient scores, NDS represents the composite nutrient score of a product. Considering the nutrient density in environmental comparisons of food products may lead to different conclusions compared with traditional FUs, and, consequently, to different recommendations about how to alter consumer choices to the benefit of the environment (Smedman et al., 2010). To our knowledge, no study exists that compared LCA results of diet scenarios while accounting for overall nutritional quality.

The main objective of our study, therefore, was to explore if accounting for nutritional quality affects the comparison of the environmental impacts of human diets varying in their percentage of ASFP. We thus reviewed studies that used LCA to evaluate the environmental impact of diets varying in percentage of ASFP. We observed that these studies were generally based on a comparison among meals or daily diets. An additional objective, therefore, was to explore whether meals or daily diets are equally suitable to compare environmental impacts of diets.

To fulfil these objectives, we used the environmental impacts as published in selected studies and expressed these impacts relative to the protein concentration of the diet or the nutritional quality of the diet. The nutritional quality of the diet was computed based on the Nutrient Rich Food 9.3 (NRF9.3) score of a diet. We chose NRF9.3 out of available nutritional quality scores (Darmon et al., 2009; Fulgoni et al., 2009), as it was best validated against the Healthy Eating Index (Fulgoni et al., 2009). We computed the protein percentage or the nutritional quality score of the diet based on information given in published papers.

2. Material and methods

2.1. Selection of studies

We searched literature in Scopus and Web of Science. Our search terms were: diet, food, meal, human nutrition, consumption pattern, life cycle, footprint, environment, greenhouse, and land use.

We defined the following inclusion criteria:

- the study contains more than one within-country diet scenario; Multiple scenarios per study were required, as studies define different system boundaries, and, hence, scenarios could only be compared within study.
- diet scenarios within studies vary in their percentage of animal source food product (ASFP);
- the weight of each food product included in the diet scenarios is given, or could be provided by the author(s);
- the study assesses global warming potential, land use or both;
- diet scenarios are not designed for specific groups (e.g. infants, people with health problems), and if diets are gender specific, we should be able to average these. Scenarios designed for specific groups were excluded, as individuals in these groups may have specific nutrient requirements, while the nutrient density score was computed using average nutrient requirements per person;
- the study is published in a peer-reviewed scientific journal.

2.2. Calculation of individual nutrient scores of each diet

For each diet scenario we quantified the daily intake of nine qualifying and three disqualifying nutrients when consuming the diets. The nine qualifying nutrients were (the recommended daily value (RDV) is given in brackets): protein (57 g) (EFSA, 2012), fibre (25 g) (EFSA, 2010), calcium (800 mg), iron (14 mg), magnesium (375 mg), potassium (2000 mg), and vitamins A (800 μg), C (80 mg) and E (12 mg) (EU, 2008). The three disqualifying nutrients were (the maximum recommended value (MRV) given in brackets): sodium (2400 mg), saturated fat (20 g) and total sugar (90 g) (EFSA, 2009). To quantify the daily intake of these 12 nutrients, we multiplied the daily intake of each food product in the diet scenario by the nutrient content of that food product. Contents of the 12 nutrients in various food products were derived from the Dutch nutrients database NEVO (NEderlands VOedingsstoffenbestand) (RIVM, 2011). The description of food products in the included studies was often less detailed than the description of food products in NEVO. We linked each food product in included studies to a product in NEVO, by using the following successive criteria:

- exact match between product description in the included studies and in NEVO. Unless the product was specified as 'raw' in the included studies, we chose the food product in NEVO in the form in which it would be consumed (e.g. boiled or otherwise prepared). When the product was only available in raw form, we chose this;
- match between product description in the included studies and in NEVO, with the additional description of 'average' in NEVO;
- the variant of the food product (e.g. 'apple juice' as a variant of the food group 'fruit juice') which had the highest consumption rate within the food group according to the Dutch National Food Consumption Survey (RIVM, 2010) in the age of 19–69 years.

Moreover, included studies did not mention the exact cut of meat consumed. We formulated, therefore, a composite meat cut per livestock species. The composite meat cut was created by combining cuts per livestock species that together sum up to a minimum of 60% of Dutch consumption volumes (RIVM, 2010), starting with the cuts that are consumed most. The consumption volumes of the various selected meat cuts form the weighing basis for computing the nutrient content of the composite cut. For the various selected meat cuts we chose the form in which it would be consumed when available in NEVO.

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