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Sustainable meat consumption: A quantitative analysis of nutritional intake, greenhouse gas emissions and land use from a Swedish perspective

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ABSTRACT

Background: Food consumption is one of the most important drivers of environmental pressures. Adoption of healthy diets is suggested to be an option for less environmentally intensive food habits and improved public health. In particular, changes in meat consumption are believed to bring potential benefits.
Objective: To quantify the impact of changes in meat consumption on the dietary contribution of nutrients, GHG emissions and on land requirement.
Design: Scenario analysis is performed for three scenarios representing different variants of meat consumption in Sweden. The reference scenario is based on average Swedish meat consumption while NUTR-1 and NUTR-2 are hypothetical scenarios in line with prevailing dietary guidelines. The results are evaluated in relation to the recommended daily intake of nutrients, international climate goals and global capacity for sustainable expansion of agricultural land. Uncertainties and variations in data are captured by using Monte Carlo simulation.
Results: Meat consumption in line with nutritional guidelines, implying an approximate 25% reduction of Swedish average intake, reduces the contribution of total and saturated fat by 59–76%, energy, iron and zinc by about half and protein by one quarter. Restrictions in meat consumption are most critical for the intake of iron and zinc, whereas positive effects on public health are expected due to the reduced intake of saturated fat. Aligning meat consumption with dietary guidelines reduces GHG emissions from meat production from 40% to approximately 15–25% of the long-term (2050) per capita budget of sustainable GHG emissions and the share of per capita available cropland from 50% to 20–30%.
Conclusions: This quantitative analysis suggests that beneficial synergies, in terms of public health, GHG emissions and land use pressure, can be provided by reducing current Swedish meat consumption.

Introduction

Diet and nutrition are major determinants for maintaining health and preventing non-communicable diseases (WHO/FAO, 2003). During the past decades, a transition towards energy-dense diets and sedentary lifestyles have resulted in a global epidemic of overweight and obesity, affecting a fifth of the world's adult population (Finucane et al., 2011; WHO, 2012). Apart from the impact on public health, food consumption has been identified as one of the most important drivers of environmental pressures (UNEP, 2010a). Food is estimated to be responsible for 20–60% of environmental impact, including greenhouse gas (GHG) emissions, eutrophication, acidification and eco-toxicity from European household consumption (Weidema et al., 2008) and account for about 30% of global anthropogenic GHG emissions (Garnett, 2011). To avoid dangerous and irreversible effects of climate change on the ecosystem it is argued that global GHG emissions need to peak within the coming 10–15 years (IPCC, 2007a), which will require substantial mitigation efforts on all fronts not least in the food sector.

A growing body of literature suggests that the adoption of healthy diets could offer multiple benefits, including improved

Abbreviations: GHG, greenhouse gas; REF, reference scenario; NUTR-1, nutrition one scenario; NUTR-2, nutrition two scenario; RDI, recommended daily intake; LCA, life cycle assessment; CO_2e, carbon dioxide equivalent.

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public health and potentially reduced environmental impact (McMichael et al., 2007; Saxe et al., 2013; Scarborough et al., 2012; Briggs et al., 2013). A reduced consumption of meat in favour of plant based foods has in particular been demonstrated to bring potential benefits in regions with affluent diets (McMichael et al., 2007; Saxe et al., 2013; Scarborough et al., 2012; de Boer and Aiking, 2011; González et al., 2011). The knowledge of how nutrient intake from different diets is affected by changes in meat consumption is, however, still limited (Westland and Crawley, 2012). Meat is a good source of many minerals (iron, zinc and selenium) and vitamins (vitamin D, riboflavin, B_{12}) and contains all the essential amino acids (Millward and Garnett, 2010). A high intake of meat has, however, been associated with an excessive intake of energy, cholesterol and saturated fat, which are known risk factors for coronary heart disease (Baxter et al., 2006; Micha et al., 2010). Red (beef, lamb and pork) and processed meat (bacon, salami, sausages, hot dogs, etc.) have in addition been associated with an increased risk of certain cancers (Ferguson, 2010; WCRF/AICR, 2007). Food of animal origin is in general also more climate and land intensive compared to food of vegetable origin (Garnett, 2009; González et al., 2011; Wirsenius et al., 2010).

In a future development of holistic guidelines and policy tools promoting more sustainable food consumption it is essential to consider both health and environmental aspects. Nutritional aspects have previously been included in environmental analysis in various but often limited ways, for instance, as a determinant of the functional unit in life-cycle assessments (LCA) (González et al., 2011; Smedman et al., 2010; Vieux et al., 2012), in scenario analysis (Tukker et al., 2011; Wolf et al., 2011; Temme et al., 2013) and in qualitative discussions (Garnett, 2008; Millward and Garnett, 2010). However, there is currently a lack of studies that have analysed the effect of dietary change in a broader perspective and of studies in which the effect on both nutrition and environment has explicitly been quantified (Hallström et al., 2011).

The objective of this study is to quantify the impact of changes in meat consumption on the dietary contribution of nutrients, GHG emissions and on land requirement, in order to identify beneficial synergies (and potential conflicts/drawbacks) for more sustainable food consumption patterns. This, in turn, could be used as a motivation for more integrated policies within the food, climate and agriculture sector.

Methodology and assumptions

Scope of the study

Scenario analysis is performed for three scenarios representing different variants of meat consumption in Sweden. The reference scenario (REF) is based on current average Swedish meat consumption while NUTR-1 and NUTR-2 are hypothetical scenarios in which meat consumption is based on criteria from the perspectives of nutrition and health. In NUTR-2 also criteria for efficient use of resources in the production system are considered. The scenarios are developed to represent Swedish conditions in a near-term perspective but are also applicable to countries where meat consumption is based on similar production systems. The results are presented per capita and are evaluated in relation to the recommended daily intake of nutrients, international climate goals and the global capacity for sustainable expansion of agricultural land.

This paper analyses solely the effects of changes in meat consumption while the composition of the remaining diet is assumed to be unchanged. The study design is chosen, firstly, to account for the total potential of reducing GHG emissions and land use by changing meat consumption according to the studied scenarios, and secondly, to analyse to what extent meat in the Swedish diet needs to be replaced by other foods from a nutritional perspective.

Per capita supply of meat differs from the actual intake due to losses and wastage along the chain of supply and handling. Hence, quantification of nutrient intake needs to be based on consumption data while production data, which refer to the available agricultural supply, is used to quantify environmental impacts. In this study quantification of nutrient intake is based on the per capita supply of bone-free, uncooked meat available for human consumption, including wastage during production and retail. The results of this study should thus be interpreted as the supply of nutrients that is theoretically available for consumption if no meat is wasted at the consumer level. The effect of wastage at consumer level on nutrient intake and environmental impact from meat is further discussed in Section 'Limitations and uncertainties'.

To capture the uncertainty and variation in nutrient content, GHG emissions and land use, Monte Carlo simulation was used (Rubinstein and Kroese, 2007). In Monte Carlo simulation, parameters are described by a probability distribution, rather than a single deterministic value, and the calculation is repeated a number of times, here 10,000; each time randomly drawing a parameter value from the probability distribution. The result of a Monte Carlo analysis consists of a number of possible outcomes of the calculation, hence giving a representation of the probability of different results depending on the uncertainty and variation in the input data.

For this article a section of complementary materials is available, in which the methodological approach, made assumptions and an extensive literature review are described in detail.

Scenario description

REF

This reference scenario (REF) is designed to reflect current average per capita consumption of meat in Sweden. Total meat consumption amounts to 169 g uncooked, pure meat (i.e. excluding bones and non-meat ingredients in charcuteries) per day, with beef, pork and chicken accounting for 30%, 47% and 24% of the total intake, respectively (Table 1). These amounts are based on data from national statistics (data for 2009), which refer to the per capita supply of meat available for consumption after adjustment for losses between the production and household level (i.e. amounts purchased at retail and "away-from-home consumption") (SBA, 2011). A detailed description of assumptions made in the development of the reference scenario is found in the section of complementary materials.

NUTR-1

The amount of meat consumed in this nutrition one scenario (NUTR-1) is based on prevailing dietary guidelines. Total meat consumption is limited to 126 g uncooked, pure meat per day (excluding 47% of non-meat content in mixed charcuteries), as suggested by the Swedish Food Authority (Enghardt Barbieri and Lindvall, 2003). Consumption of red meat is restricted to 60 g (uncooked weight) per day (50% beef, 50% pork) and consumption of charcuteries is reduced to zero, which corresponds to the public health recommendation by the World Cancer Research Fund (e.g. max 300 g cooked, equivalent to 400–450 g uncooked, red meat per week, avoid processed meat) (WCRF/AICR, 2007).

NUTR-2

As in NUTR-1, the total meat consumption in this nutrition two scenario (NUTR-2) is limited to 126 g uncooked meat per day and the intake of charcuteries is reduced to zero. In this scenario, the beef comes entirely from production systems that produce both milk and meat, which are more resource efficient than systems producing only meat, since the emissions from enteric fermentation, feed production, etc. can be split between the milk and the meat. As a co-product from combined meat and milk production,