Assessing food-based dietary guidelines from a resource use perspective

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Abstract

Reducing animal-source food (ASF) consumption is often proposed as a strategy to both reduce environmental impacts of food systems and improve diet quality. Food-based dietary guidelines are a common starting point for dietary improvements. However, these guidelines are generally designed from a diet quality perspective, and hence not linked to environmental impacts of food production. Here, we assessed whether nationally recommended quantities of ASF can be produced based on low-opportunity cost feed. We investigated this in a scenario analysis using an optimisation model. In this model, feed resources are allocated to different animal production systems in order to maximise different nutritional outcomes for humans. In addition, we calculated the global warming potential of each scenarios. While recommended quantities of ASF could not be met, limiting ASF to the extent that could be produced with low-opportunity cost feed would avoid feed-food competition as well as reduce global warming potential.

Introduction

Current food production practices cause substantial environmental impacts, which makes improvements essential (Willett et al., 2019). Most improvement strategies include the reduction of **animal-source food (ASF)** (Poore & Nemecek, 2018). A concept increasingly receiving attention focuses on avoiding feed-food competition by limiting ASF to the extent that can be fed with **low-opportunity cost biomass (LCB)**. LCB includes by-products from processing, food waste, and grass resources.

From a consumers' perspective, **food-based dietary guidelines (FBDG)** are generally the starting point for dietary improvements. National FBDGs capture both geographical as well as cultural circumstances that shape not only the resources available, but also dietary habits (Pestoni et al., 2019). However, since FBDGs are designed from a diet quality perspective, their environmental performance is not necessarily ideal (Scherer et al., 2019). In particular, ASF recommendations are increasingly questioned (Springmann et al., 2020).

In this study, we therefore investigate

- whether **recommended quantities of ASF in FBDGs can be produced based on LCB**, and
- what the **environmental consequences of limiting ASF to LCB** would be.

Methodology

FBDGs
We selected five national FBDGs as case studies from different regions in Europe: **Bulgaria** (Eastern Europe), **Malta** (Southern Europe), **the Netherlands** (Western Europe), **Sweden** (Northern Europe), and **Switzerland** (Central Europe).

Modelling approach and scenarios
For each of the FBDGs, we assessed the potential for ASF based on LCB using an **optimisation model** developed by van Hal et al. (2019) (Figure 1). This model allocates LCB feed to different animal production systems (dairy, beef, layer, broiler, pig, salmon, and tilapia) in order to maximise different nutritional outcomes for humans.

We employed four **scenarios** with differing nutritional foci. In all scenarios, animal feed was limited to the LCB resulting from the plant-source food part of the FBDG of the respective country.

- In the first scenario, **MaxProt**, human-digestible animal protein was maximised,
- in the second scenario, **MaxFattyAcids**, the omega-3 fatty acids ALA, DHA, and EPA were maximised,
- in the third scenario, **MaxMinerals**, the minerals calcium, iron, and zinc were maximised, and
- in the last scenario, **MaxVitamins**, the vitamins A and B12 were maximised.

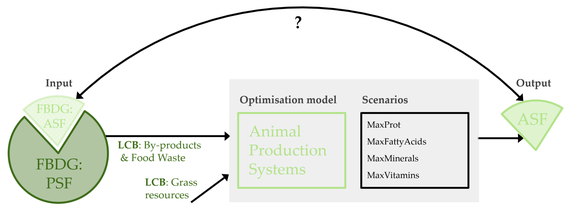

Figure 1: Illustration of the modelling approach.

Nutritional and environmental impact assessment
We quantified the following nutrients of the ASF of the original FBDGs and of the scenarios: protein, fat, calcium, iron, zinc, vitamin A, vitamin B12, and the omega-3 fatty acids ALA, DHA, and EPA. In addition, the energy content was quantified.

We computed the global warming potential (GWP) as well as land occupation (not shown) of the ASF of the scenarios relative to the ASF of the original FBDGs. For this assessment, we employed the biophysical mass flow model SOLm (Muller et al. 2017; Schader et al. 2015).

Results

Protein contents of most FBDGs exceed protein needs (50-60 g protein per capita and day) substantially (see Table 1).

Table 1: Protein content of FBDGs.

Country	Protein content (FBDG)	Protein content ASF (FBDG)	Share ASF protein / total protein FBDG
Bulgaria	93 g	44 g	0.47
Malta	60 g	34 g	0.56
Netherlands	98 g	45 g	0.46
Sweden	85 g	56 g	0.66
Switzerland	83 g	44 g	0.52

No alternative ASF scenario of any country was able to meet the protein content of the ASF recommended in the respective FBDGs (see Figure 2). For other nutrients, contents could be met in some scenarios.

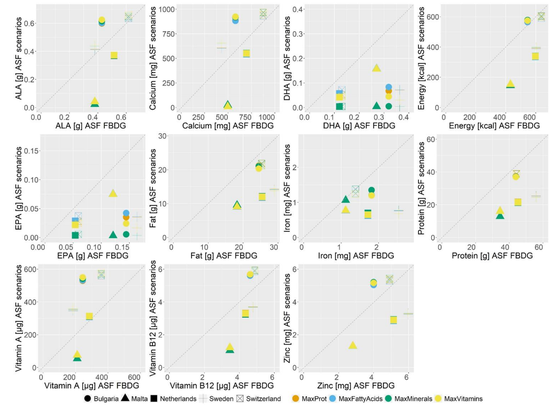

Figure 2: Nutrients of the ASF of the original FBDGs plotted against nutrients of the ASF of the scenarios (colour) and countries (shape).

All scenarios showed a strong decrease of GWP as compared to the FBDG diets, which came along with substantial reductions in available ASF.

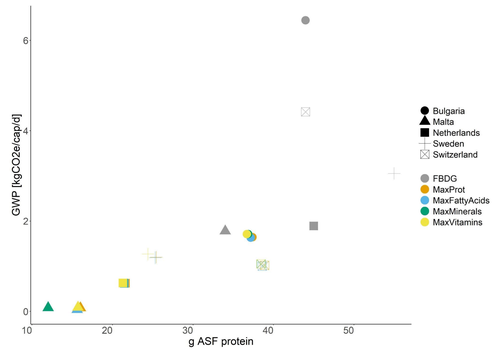

Figure 3: GWP and g of ASF protein per original FBDG and scenario (colour) and country (shape).

Conclusion

- Protein contents of the FBDGs of Bulgaria, the Netherlands, Sweden, and Switzerland exceed protein needs substantially.
- ASF recommendations of the FBDGs cannot be met when ASF production is limited to LCB.
- Depending on the nutritional function in focus, composition of ASF changes.
- The composition of ASF results in trade-offs between diet quality considerations (chicken favoured) and efficient use of LCB (cattle and partly pork favoured).

→ When **limiting ASF to LCB, feed-food competition could be avoided and GWP substantially lowered.**

→ If **protein contents of the FBDGs were adjusted to the needs, ASF from LCB could provide a substantial part** of these.

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