Life cycle assessment of meals based on vegetarian protein sources

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ABSTRACT

This study investigates the environmental impacts of vegan and vegetarian food products which are rich in vegetable proteins from plants or fungi and meals prepared with such products. The main goal of the study was to provide reliable life cycle inventory data for this type of products and to assess the impacts for single ingredients and meals prepared with such products and further ingredients. This pilot study shows that the impact of vegetable protein products can only be comprehensively assessed when considering the later usage in a meal that is ready for consumption. The results of this study for some individual examples still do not allow general statements for the evaluation of vegetable proteins from an environmental perspective.

Keywords: vegetable protein, meals, ingredients, vegan, vegetarian

1 Introduction

So far, many LCA studies investigated the importance of meat in diets. These studies show that meat and animal products are responsible for a major share of environmental impacts due to food consumption (Nemecek, Jungbluth et al. 2016). Thus, alternatives are necessary which can provide similar nutritional value, but can be produced with lower environmental impacts.

LCA studies or public data for such alternatives were so far not available in Switzerland. This study investigates the environmental impacts of food products which are rich in vegetable proteins from plants or fungi (sunflower seeds, almonds, mushrooms, dried soybeans, dried chickpeas, dried lentils, canned chickpeas, soy milk, pre-fried falafel, tofu, textured soy protein and mycoprotein).

2 Goal and Scope

The main goal of the study was to provide reliable life cycle inventory data for products rich in vegetable proteins and to assess the impacts for single ingredients and meals prepared with such products in Switzerland (Jungbluth, Nowack et al. 2016).

The products are assessed as a single ingredient or as part of a home-cooked meal. The recipes for meals are prepared in a way that they provide a good balance of different nutrients. However, meals are not fully equivalent which has to be considered in the comparison and interpretation of results. The main focus was on the protein content. Other nutrients, e.g. the mineral or vitamin content of meals were not considered for this definition. The following meals are investigated in this study:

- falafel with potatoes and yoghurt sauce with herbs
- Bircher muesli (including almonds, soy milk and yoghurt)
- chickpeas with raisins and rice
- brown lentils and polenta
- rice pan with tofu and vegetables
- spaghetti Bolognese with soya mince
- quorn mince and champignon sauce, with noodles

Single ingredients represent quite different nutritional values and are thus not directly comparable. The following single ingredients are investigated as a typical portion:

- soymilk (200 ml)
- sunflower seeds (25 g)
- white mushrooms (120 g)
- soybeans, soaked and cooked (120 g)
- chickpeas, canned, warmed up (125 g)

The impact assessment methods used are the Swiss ecological scarcity method 2013 (Frischknecht, Büsser Knöpfel et al. 2013). The different products are analysed per mass, portion, calorific value and protein content.

3 Life cycle inventory analysis

Several new life cycle inventory data have been collected and documented. The investigation covers all life cycle stages from agricultural production, processing, distribution, transportation to home, cooling and preparation of the product. Food waste in different stages of the life cycle (but not including food waste after preparation of the meal) is assessed with standard factors for product categories (Flury, Jungbluth et al. 2013). The life cycle inventory analysis uses literature data and direct information by producers. The life cycle inventory data newly investigated for this project are publicly available on www.lc-inventories.ch.

4 Impact assessment

Figure 1 shows the environmental impacts per portion. Other ingredients than the main protein sources are shown in a separate section or as part of the consumption. For some products the agricultural production is the dominant stage in the life cycle e.g. sun flower seeds. Impacts for some other products, e.g. canned chickpeas, are dominated by the processing or packaging. Environmental impacts of the meals are often considerably influenced by other ingredients than the protein source. The protein source is mainly relevant in case of the meal with quorn and for the Bircher muesli.

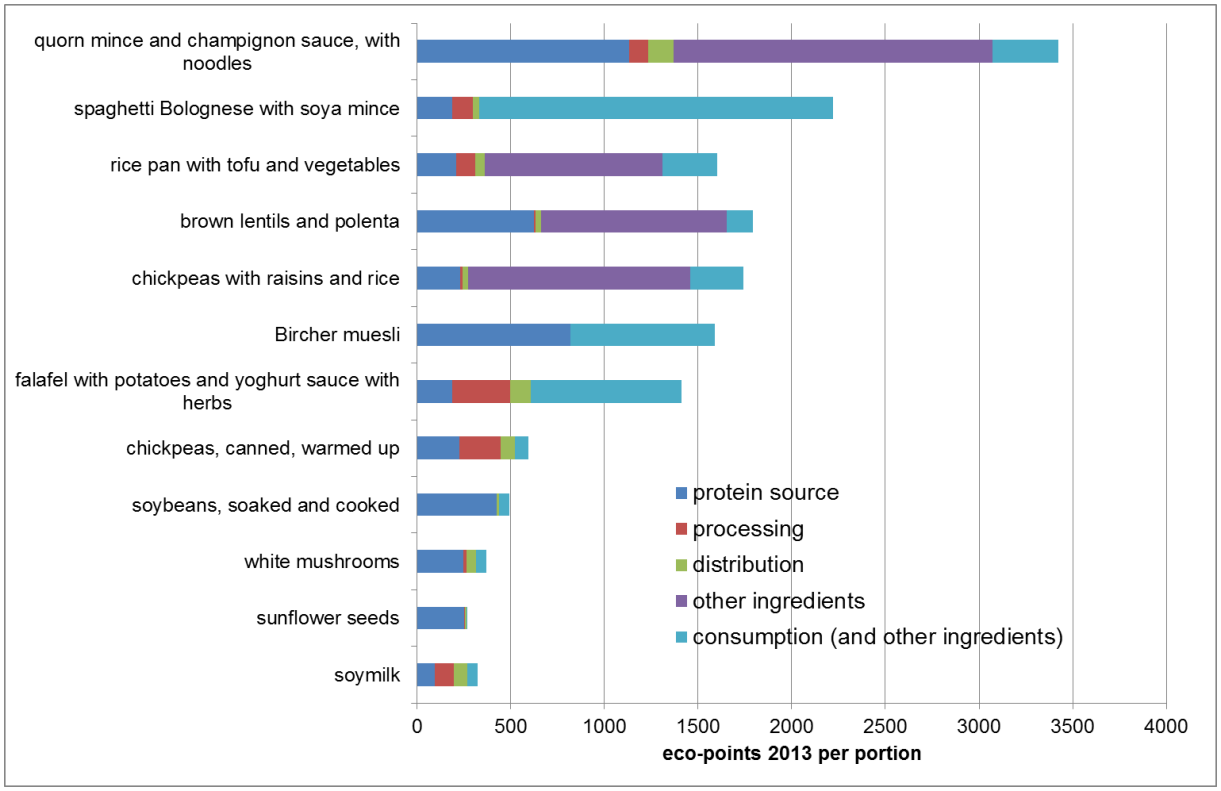

Figure 1 Environmental impacts of different single ingredients and meals (eco-points 2013 per portion)

Evaluating the environmental impacts for one portion does not reflect differences in nutritional values. Therefore impacts have also been evaluated in relation to calories and protein content of the portions. Figure 2 shows the impacts per gram of protein. Differences between different meals get less pronounced, but still the meal with quorn, which includes a large share of protein from eggs, shows the highest impacts. Mushrooms show rather high impacts due to their low protein content.

If environmental impacts are assessed in relation to the protein content, it is also important to take the biological value of the proteins for nutrition into account. For single ingredients the biological value is lower than for different well combined protein sources. In order to achieve a high biological value and thus a high availability of proteins it is necessary to smartly combine different food products (e.g. rice and lentils, maize and beans, potatoes and milk). This helps to cover the amount of essential amino acids required. The recipes used in this study are based on such considerations.

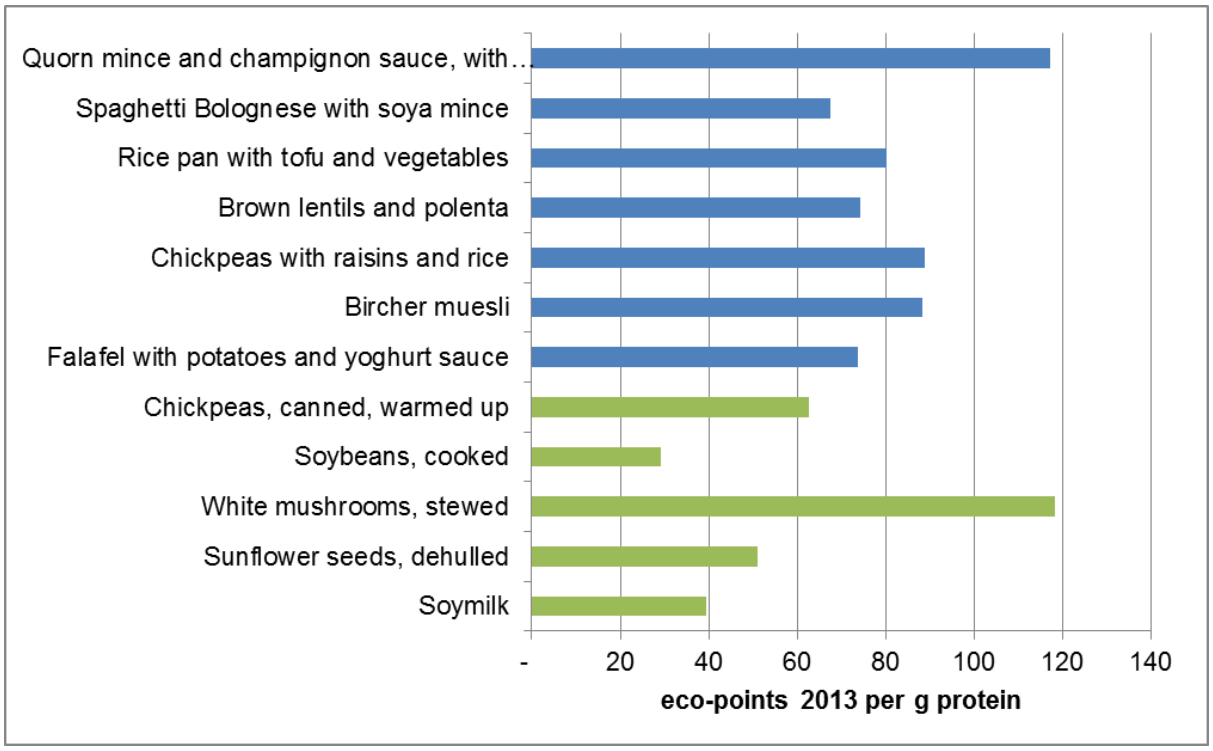

Figure 2 Environmental impacts of different single ingredients (green) and meals (blue) (eco-points 2013 per g protein)

Another evaluation in relation to the energy content of the meals and single ingredients is made in Figure 3. Again mushrooms have a low nutritional value and thus higher impacts than other single ingredients or meals. The ranking between different meals changes with this functional unit and e.g. quorn does not have so much higher environmental impacts than other meals anymore.

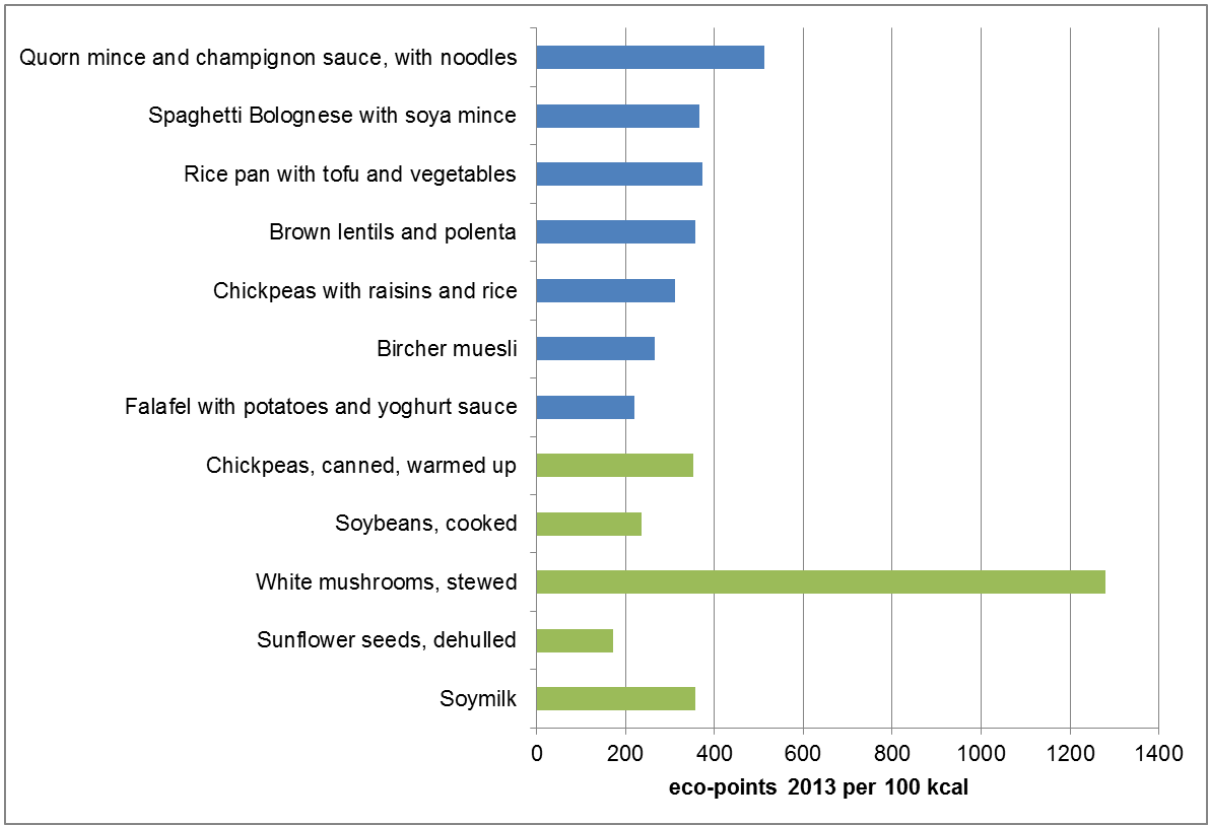

Figure 3 Environmental impacts of different single ingredients (green) and meals (blue) (eco-points 2013 per 100 kilocalories)

The results of adequate meals with vegetarian proteins can also be compared with typical meals including meat or fish as a protein source (Stucki, Jungbluth et al. 2012; Jungbluth, Flury et al. 2013-2016). This evaluation shows that the impacts of meals based on vegetarian proteins are lower than meals including fish or meat, but also provide sufficient nutritional value (Figure 4). For most of the products, the main impacts over the life cycle arise from effects due to land occupation, climate change, air and water pollutants.

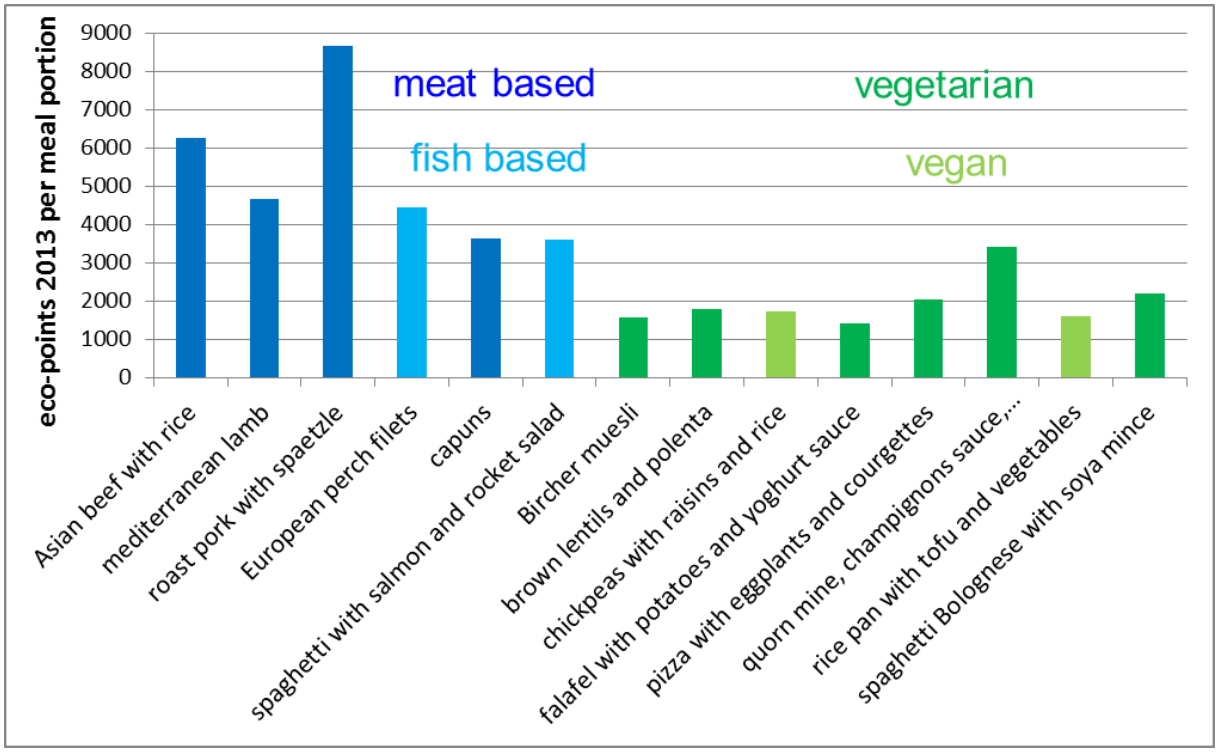

Figure 4 Environmental impacts of different meals (eco-points 2013 per portion)

5 Implications

This pilot study shows that the impact of vegetable protein products can only be comprehensively assessed when considering the later usage in a meal that is ready for consumption. An evaluation at a preliminary production stage or at the level of a single ingredient is not sufficient for a comprehensive assessment because the combination of protein rich products with other ingredients has a decisive effect on the nutritional value and the environmental impact. Another conclusion of the study is that the environmental impact of food should be specified not only per kilogram or per portion but also per nutrient content.

This study investigates only some examples of products rich in vegetable proteins. The results of this study for some individual examples still do not allow general statements for the evaluation of vegetable proteins from an environmental perspective.

The study lays the foundation for more detailed assessments by developing the necessary methodology and providing transparent data. Furthermore, the data are used for studying the environmental impacts of food consumption patterns (Jungbluth, Eggenberger et al. 2016).

6 References

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