Project Report

Product Environmental Footprint (PEF) of Protein Concentrate from Organic Grass – A preliminary investigation

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1. Goal

The goal of this study was to implement a product environmental footprint (PEF) study of protein concentrate from organic grass under the auspices of the Grass-prof project, funded by the Green Development and Demonstration program of the Ministry for the Environment in Denmark (GUDP, Ministry of Food, Agriculture and Fisheries). The PEF study shall calculate the environmental footprint (EF) of the various impact categories (climate, environment, human toxicity etc.). The proteinaceous feed is defined as protein concentrate which is produced from organic clover grass (from now on will be referred to as grass protein concentrate, GPC) through a specific technology developed in Denmark and is implemented in the Ausumgaard biorefinery plant.

The intended audience is members of the Grass-prof project and also agricultural organizations, more specifically feed producing industry, that have shown an increased interest in products that perform well environmentally and can potentially replace imports of soybean. Thus, the goal was to work with the project and project members' data and analyze the PEF of GPC from organic grass. The PEF of GPC can later be used as input for the early assessment of PEF of compound feed formulations that may use this GPC as a feed ingredient.

The methodology used herein is in line with the PEFCR guidelines set by the European Commission (European Commission. 2018), specific regulations of "PEFCR of feed for food-producing animals" (European Commission. 2020). Furthermore, this was also supplemented with the LEAP guidelines (FAO 2014) when necessary, as outlined in this report.

2. Scope

The scope of this PEF study is the organic GPC which is produced in Ausumgaard biorefinery in Denmark and is intended to be used as a proteinaceous feed ingredient in local animal farms. However, the scope can be further expanded to cover the production of GPC with other technologies in Denmark or in other European countries, as well as the production of compound feeds with GPC and PEF study of food-producing animals fed with GPC. Hence, the scope of this study covers the activities that take place on Ausumgaard farm, from grass cultivation to finished GPC product, ready to be sold to the market.

This PEF study has been implemented in line with the recommendations made by PEFCR Feed for Food-producing Animals (European Commission. 2020) and according to the stages shown in Figure 1. During these stages, the PEF study was conducted, and potential barriers, limitations, and bottlenecks were identified, and possible solutions were proposed. This report is not critically reviewed by external reviewers, so the review shown in Figure 1 refers to an internal review by project partners.

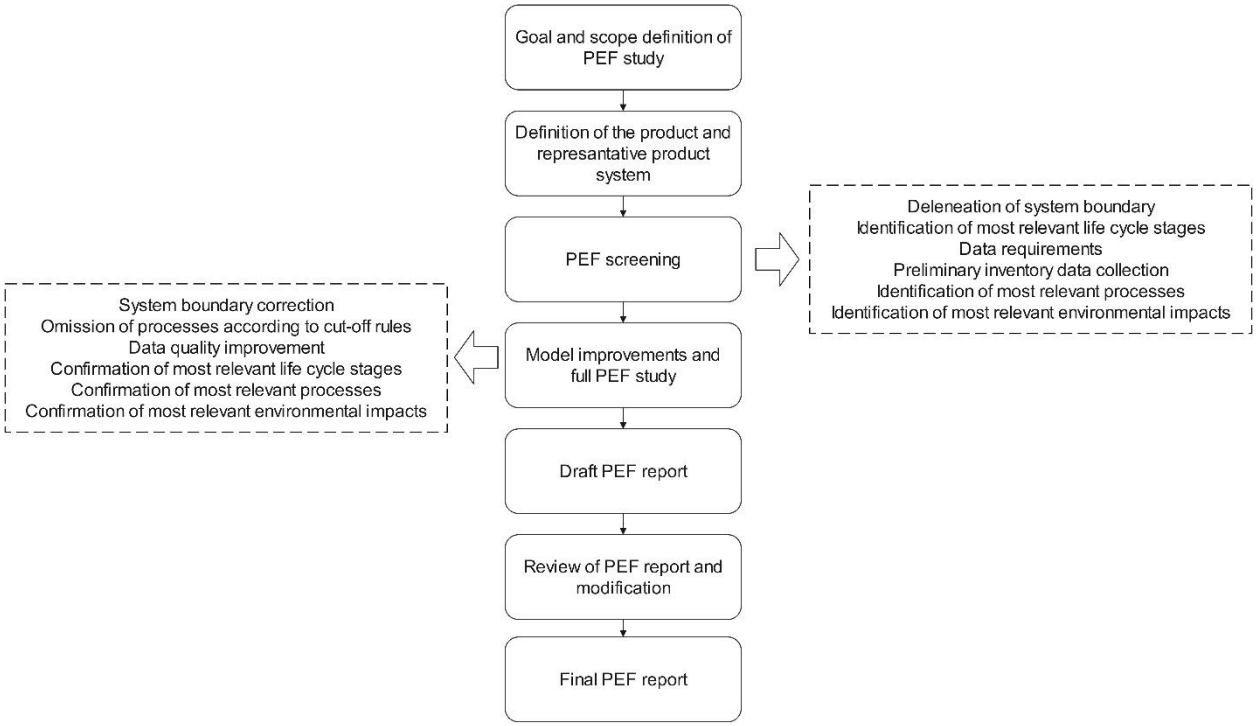


Figure 1. The steps followed in this PEF study

A cradle to gate system boundary (Figure 2) was opted for this PEF study as instructed by PEFCR Feed for Food-Producing Animals (European Commission. 2020). This includes two main life cycle stages, i.e., clover-grass cultivation and its processing to GPC, which need mandatory company specific data collection. The production of auxiliaries, capital goods, energy carriers, packaging materials, etc. are also included but they also need secondary data to link the activity data to the background systems where the energy carriers, chemicals, and materials are produced to fulfill the requirements of the PEF studies.

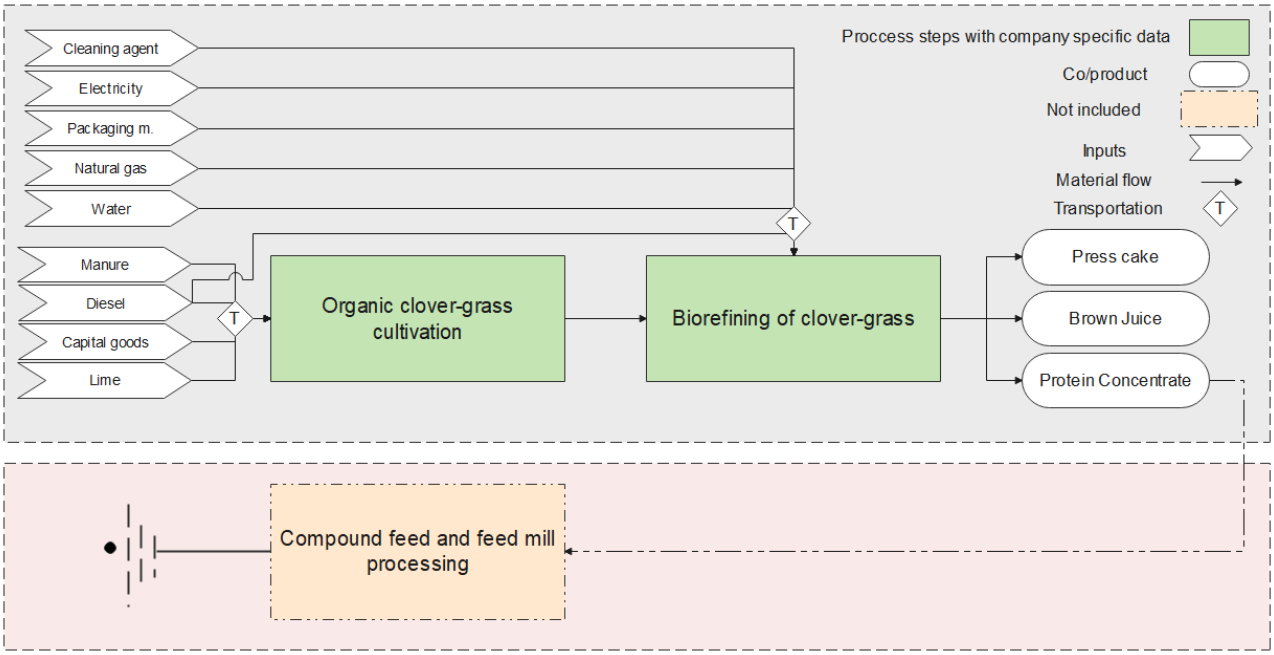


Figure 2. System boundary for the assessment of organic protein concentrate from clover grass, including indication of the processes for which company-specific data are mandatory

Feed is an intermediate product which means that no functional unit is considered as such (European Commission. 2020). The declared unit (equal to reference flow) is considered instead. The reference flow is 1 ton of GPC as finished product, ready for sale. That is, 1 ton of protein concentrate with a dry matter content of 90%. All quantitative input and output data collected in this study shall be calculated in relation/scaled to this reference flow.

3. Life Cycle Inventory

An inventory of all material, energy and waste inputs and outputs and emissions into air, water and soil for the product supply chain shall be compiled as a basis for modelling the PEF. This is called the life cycle inventory. In general, there are two types of inventory data:

1- Company-specific data (also called activity data): it refers to directly measured or collected data representative of activities at a specific facility or set of facilities. It is synonymous to "primary data".
2- Secondary dataset: refers to data not from the specific process within the supply-chain of the company performing the PEF study. This refers to data that is not directly collected, measured, or estimated by the company, but sourced from a third-party life-cycle-inventory database or other sources. Secondary data includes industry-average data (e.g., from published production data, government statistics, and industry associations), literature studies, engineering studies and patents, and can also be based on financial data, and contain proxy data, and other generic data. Primary data that go through a horizontal aggregation step are considered as secondary data.

Data needs matrix (DNM), as shown in Table 1, can be used to decide whether company-specific data or secondary data shall be used for each process. The data quality must be calculated after rules for Data Quality Rating (DQR) (Zampori and Pant 2019).

Table 1. Data Needs Matrix (DNM) – Requirements for a company performing a PEF study. The options indicated for each situation are not listed in hierarchical order

		Data requirements
Situation 1: process run by the company	Option 1	Provide company-specific data (both activity data and direct emissions) and create a company-specific dataset. Calculate the Data Quality Rating (DQR) of the dataset.
Situation 2: process not run by the company but with access to company-specific information	Option 1	Provide company-specific data and create a company-specific dataset. Calculate DQR of the dataset.
	Option 2	Use a secondary dataset that is Environmental Footprint (EF)-compliant and apply company-specific activity data for transport (distance), and substitute the sub-processes used for electricity mix and transport with supply-chain specific EF compliant datasets. Recalculate DQR of the dataset.
Situation 3: process not run by the company and without access to company-specific information	Option 1	Use an EF-compliant secondary data set in aggregated form. Recalculate DQR of the dataset.

4. Handling Multifunctional processes

In the actual PEF-study the biorefining of clover-grass goes into three output flows: fiber, brown juice, and grass protein concentrate. This is referred to as a multifunctional process and the PEF results has to be allocated to the three output flows. The PEFCR feed for food-Producing animals has suggested using a hierarchical approach as described in the LEAP Guideline: 'Environmental performance of animal feeds supply chains (pages 36-43), FAO 2015, available at http://www.fao.org/partnerships/leap/publications/en/'. Following the guidelines and considering that GPC is an intermediate product and should be used as ingredient for compound feed production, the decision was made that economic allocation at the biorefinery life cycle stage can be more representative. Accordingly, the environmental burdens were allocated to three flows according to the product economic value. Since economic allocation was used in this PEF study, the final application of coproducts including biogas production was not included in the system boundary and in the scope of this PEF study.

5. PEF secondary datasets

To perform the PEF study, the data from foreground systems (e.g., electricity consumption) needs to be linked to the background processes where energy carriers, chemicals, materials, etc., are produced. PEF studies shall use PEF secondary datasets for the background processes. PEF secondary datasets refers to general data not coming from a specific process within the supply-chain of the company performing a PEF study. Secondary datasets must be approved in the PEFCR system. A list of approved databases with secondary data are available on EU website at: https://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR_en.htm.

6. PEF results

The EF of GPC in the impact category of climate change is calculated at 1091.47 kg $CO_{2,\,eq}$/t GPC. The cultivation stage had the highest contribution to the climate change impact category, i.e., 1.7 times as high as impacts of biorefinery stage (Figure 3). Clover-grass cultivation contributed to 63% of climate change impact (689.1 kg CO_2,eq). Emissions from the application of manure and lime were the most dominant contributors to this damage category. Specifically, 33% of the overall impacts originate from greenhouse gases from manure and slurry application. Direct emissions from the combustion of fuels in biorefinery stage is found to be the second important contributor to this impact category.

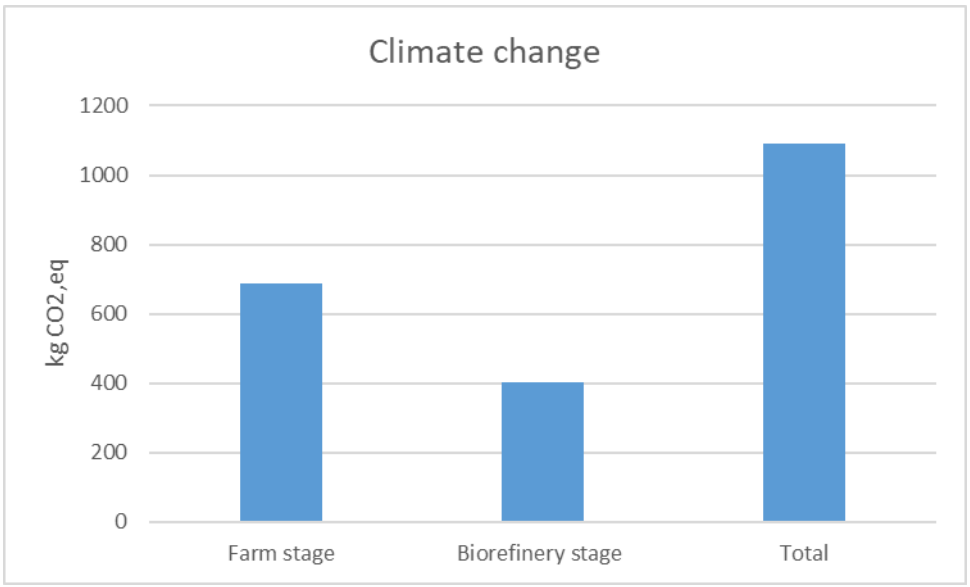
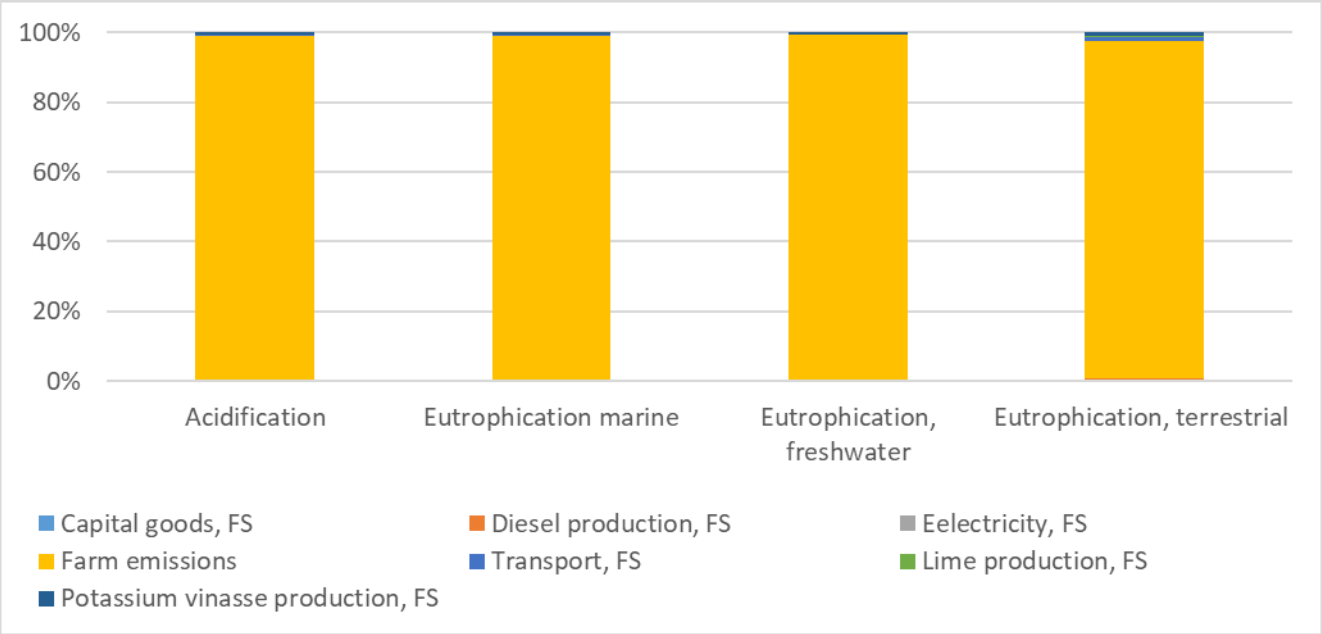


Figure 3. Environmental Footprint of grass protein concentrate

On average 62% of the overall environmental impacts in all impact categories originated from the cultivation stage. However, the impact from cultivation stage on each impact category differ significantly. In Acidification, Eutrophication freshwater, Eutrophication marine, Eutrophication

terrestrial as shown in Figure 4, direct emissions dominated the overall impact category. Direct emissions in these impact categories refer to the



Acidification	41.55709	mol H+ eq
P 1. Nitrogenous Emissions, manure application V2.1	41.46440	mol H+ eq
F ammonia - DK	41.46440	mol H+ eq
Eutrophication marine	22.17321	kg N eq
P 1. Nitrogenous Emissions, manure application V2.1	22.12642	kg N eq
F nitrate	22.12642	kg N eq
Eutrophication, freshwater	0.62233	kg P eq
P 1. P Emissions, manure application V2.1	0.61344	kg P eq
F phosphorus, total	0.61344	kg P eq
Eutrophication, terrestrial	72.13980	mol N eq
P 1. Nitrogenous Emissions, manure application V2.1	72.13428	mol N eq
F ammonia - DK	72.13428	mol N eq

Figure 4. Contribution analysis for four impact categories of Eutrophication marine, Eutrophication freshwater, Eutrophication terrestrial and Acidification with key contributor

Grass protein concentrate has, on average, 47% crude protein of dry matter. This product can substitute organic protein feed ingredients such as organic soybean, and soybean meal in compound feeds. PEF secondary dataset lacks organic products; hence, it was not possible to compare the environmental footprint of organic grass protein with organic feed ingredients. In order to give an

overview of how environmentally friendly grass protein is, it was compared against conventional soybean and soybean meal. According to the protein content grass protein concentrate can on average substitute 1204 kg soybean with a crude protein content of 40% of dry matter (https://www.feedipedia.org/node/42) and 917 kg soybean meal with a crude protein content of 52% of dry matter (https://www.feedipedia.org/node/674). The results showed that the climate change impact of grass protein concentrate production is 24% of average globally soybean production. According to the PEF secondary dataset, climate change impact of average soybean production in EU is 34% of that of global average, hence, grass protein concentrate has also lower impact than soybean production in EU. The detailed comparison can be seen in Figure 5.

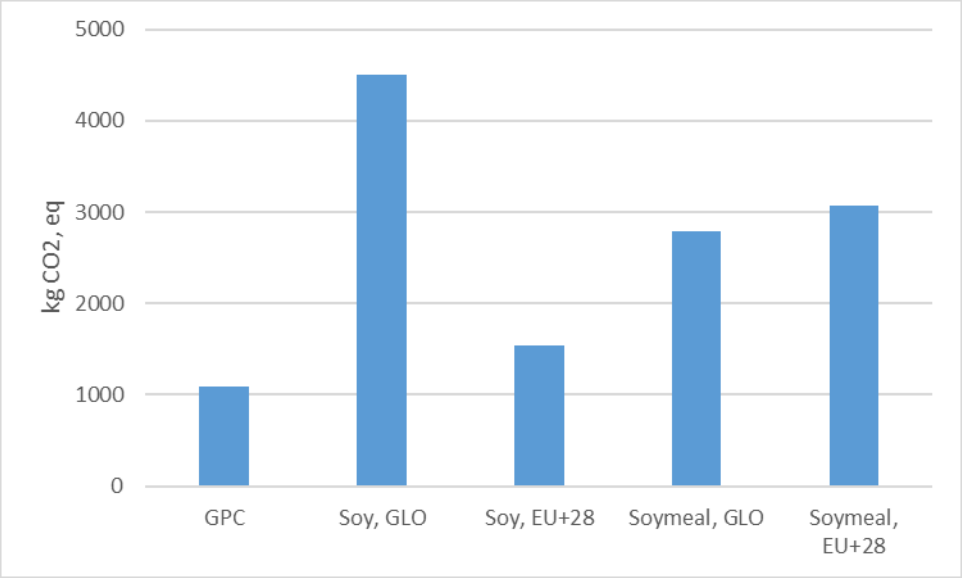


Figure 5. Environmental impacts of GPC, soybean and soybean meal in climate change impact category. GLO stands for average global production, EU+28 stands for average production in EU.

7. Prospective work

In the next phase of this project, we are using PEF method to quantify the environmental impacts of compound feed with and without grass protein. The system boundary includes the production of feed ingredients, feed milling and processing, and transportation.

Data accessibility

A comprehensive and detailed report of this PEF study will be available. The detailed PEF report and all supplementary data and files can be shared on reasonable request.

Acknowledgment

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