Rapport GrasGoed

Natuurlijk Groen als Grondstof

LCA summary report

Grass protein versus Soy protein

Partners

Steun

Report

LCA summary report

Grass protein versus Soy protein

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DISCLAIMER

The Life Cycle Assessment described in this report is performed according to ISO 14040 and ISO 14044 standards and aims to comply with LCA definitions. This (summary) report contains information from multiple sources which are accurate and reliable to the best of our knowledge. However, both technical and methodological aspects will change over time due to new technical developments and insights. Because of this we strongly advise NOT to use the outcomes of this study after 1st of April 2023.

The outcomes of this study are intended for (ecological) optimization purposes for the products/services of Grassa and partners only. For liability, we refer to article 9 of the general terms of delivery of Avans (see: https://www.avans.nl/binaries/content/assets/nextweb/over-avans/organisatie/inkoop_leveringsvoorwaarden.pdf).

Content

1. Introduction

1.1 Cause & background

The LCA is made in scope of the EU Interreg Vlaanderen-Nederland project: GrasGoed – Natuurlijk groen als grondstof. The aim of GrasGoed is to utilize grass clippings from nature reserves as an innovative raw material. Grassa developed a biorefinery process to valorise grass into multiple products.

Although the utilization of residual streams like grass is considered sustainable, it has not been quantified for the specific process from Grassa. The current study aimed to quantify the environmental impacts for the biorefinery of grass by means of the Grassa technology. This technology delivers multiple products of which one is protein that can be applied as chicken feed. The request of Grassa to the Centre of Expertise Biobased Economy at Avans Hogeschool was to compare the environmental impacts of this biobased product to the impacts of its conventional alternative: soy protein as chicken feed.

1.2 Goal

The purpose of this study is to assess the environmental impacts of proteins from natural grass for application in chicken feed. These impacts will be compared to the environmental impacts of soy protein. For both scenarios, an LCA was performed. The purpose of these LCA's is to show the differences in environmental impact. The results will be used to substantiate the sustainability claims for grass products.

1.3 Product system & Boundaries

The product system for the Grassa scenario is shown in figure 1. Here it can be seen which processes are taken into account to calculate the environmental impacts of the product. It was assumed that the grass feedstock for the biorefinery is 50% natural grass, which comes available from maintenance of nature reserves, and 50% cultivated grass. The natural grass would grow and be mowed anyway, as a maintenance process, so even if it is illustrated in the graph for sake of clarity, there are no impacts related to it. Once the grass is harvested it is transported to the biorefinery facility (average transport distance of 10 km). The biorefinery process delivers multiple products of which protein meant for chicken feed is one. Also (clean) water is one of the outputs. This water is directly extracted from the grass after the biorefining process and can be discharged into the sewer. The mineral concentrate can be used as a fertilizer, the ensiled fibers can be fed to cows and the FOS, for its properties, can replace sugar in the market. Thus, those substances were credited as illustrated in 2.2.

In both scenarios the END OF LIFE PHASE is not included since the proteins will be used as chicken feed. Therefore the use phase is also considered to be the end of life phase.

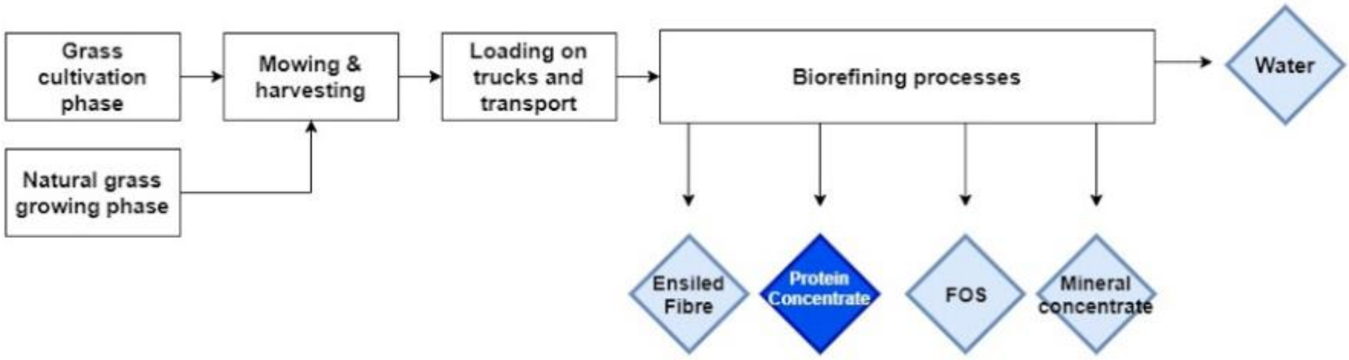

Figure 1: Product system of grass protein scenario (the end of life phase is NOT included in the computations, see text)

Figure 2 is representing the reference case which is starting with the soy cultivation phase. The soy will be harvested and transported. In the Netherlands, the majority of soy protein is imported from South America. That's why a transport distance of 9000 km per ship is included which is the average distance from South America to the port of Rotterdam. The soy is then processed into soy protein, which is meant for chicken feed, and soy oil. The soy oil has a very similar use to other edible oil, so it was decided to credit it with palm oil since the production of soy oil will replace the production of the same amount of palm oil.

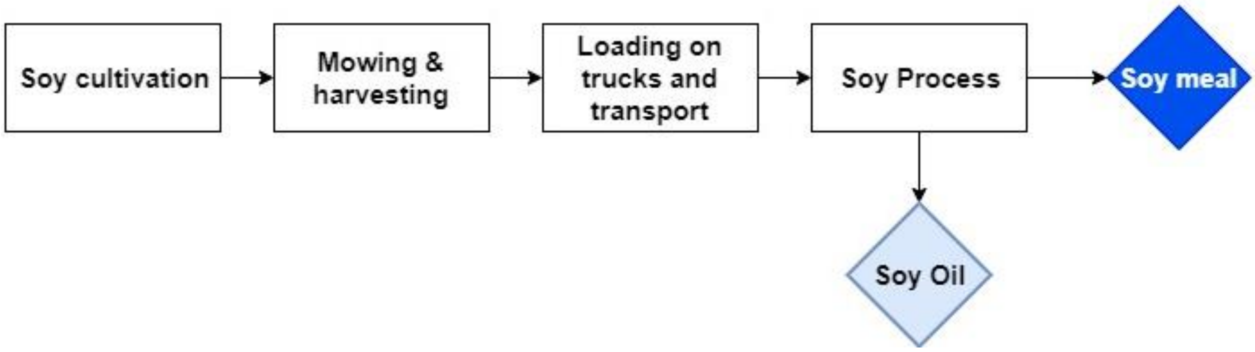

Figure 2: Product system of soy protein scenario (the end of life phase is NOT included in the computations, see text)

2. Methods & data

2.1 Methods

The LCA has been modelled by using LCA software GaBi. Below the most important methods and choices from this study are described.

Functional unit and reference flow

Since the LCA aims to make a comparison between proteins from natural grass and proteins from soy, the functional unit is a meal of chicken feed with the same raw protein content. In order to be able to compare this, the reference flow is based on the weight of the proteins that are obtained from the processes. The grass contains 19% protein. Starting from 79 kg of grass, 30 kg of grass meal can be obtained with a raw protein content of 50% this amounts to 15 kg of protein. For the soy, 32.25 kg of soy meal will be necessary (taking 46.5% as average protein content) in order to obtain the same amount of raw protein.

By-products and allocation

The life cycle of the products results in several products that are not directly of interest for the modelled process, but that are valuable and that can replace other products on the market. Since this LCA is a consequential LCA, the consequences of by-products are taken into account by means of crediting. This means that for each by-product it was checked which product it could replace in the current market. It was assumed that the by-product will replace the conventional product and therefore the impacts related to the conventional product are subtracted from the impacts of our main product. This method is called crediting.

LCIA methods

When calculating the results of an LCA, it is possible to use different impact assessment methods. Each method gives indicators of environmental impacts as a result. Environmental impacts can be expressed in different stages of the cause-effect chain; it can either be expressed as midpoints or endpoints. Endpoints are representing the environmental effects at the end of this chain while midpoints are expressed as environmental impacts earlier along the cause-effect chain. Endpoint environmental indicators are derived from midpoint environmental indicators.

The Life Cycle Impact Analysis in this research will be calculated according to the ReCiPe 2016 method (1). This method transforms the results of the Life Cycle Inventory (LCI) into 19 midpoints. These midpoints are more difficult to interpret because they consider a large number of impacts, but the results are more detailed. The midpoints can be calculated into three endpoints, which are:

- <u>Damage to human health – expressed in DALY:</u>
  DALY stands for Disability Adjusted Life Years and is a measure of overall disease burden, expressed as the cumulative number of years lost due to illness, disability or early death. It can be seen as the gap between an ideal health situation, where individuals live longer, free of disease and disability, and the loss of quality and quantity of life years. It is a quantified pre-mature mortality involved by being exposed to certain emissions.

- <u>Damage to ecosystems – expressed in species × year:</u>
  The unit for ecosystem quality is the local species loss integrated over time and can be seen as the entity of damage done to the ecosystem due to environmental emissions.

- <u>Damage to resource availability - $:</u>
  The use of fossil or mineral resources is expressed in dollar to represent the damage made to resource availability. It also includes the additional costs for future fossil or mineral resource extraction.

Perspective

Three different perspectives exist (hierarchist, individualist and egalitarian), each representing different perceptions of the world with regards to time preference, uncertainty and local preference. The hierarchist perspective is the one chosen for this comparative LCA since it is the most balanced perspective regarding to present and future impacts and regarding benefits and risks.

Normalization

The endpoint environmental impacts are normalized using ReCiPe 2006. Normalization is a principle in which you compare a certain impact to the impact which in caused by an average, in this case European, person on yearly basis.

Checks

A sensitivity analysis and a completeness check were performed.

2.2 Data & Assumptions

Data

Data about processes are obtained from Grassa, in specific from personal communication with Bram Koopmans, shareholder of Grassa. More general data for example on transport and electricity production was obtained from databases within the GaBi software.

For the soy protein scenario, a pre-made process from the GaBi database has been used.

Assumptions

In each LCA, assumptions were made in order to model reality. The most important assumptions are listed below:

- The grass in input for the main scenario is 50% cultivated grass and 50% natural grass.
- Both natural grass and cultivated grass are used in the biorefining process. The natural grass is coming without burden because nothing will change by making use of this grass since it is available without any other purpose to apply it. The GaBi database only includes one type of cultivated grass which is switchgrass. Thus switchgrass was used representing cultivated grass in the LCA. Literature studies confirmed that switchgrass can be used to represent cultivated grass.
- It was assumed that for the main scenario a biodigester is used, so that the electricity and the heat necessary for the biorefinery are directly coming from biogas.
- Clear water is an output from the process. This water is considered not having any negative effect. Since it is clean, it will be discharged into a sewer.
- Each by-product from the Grassa biorefinery process was credited.
  The ensiled fiber was credited with switchgrass for 70% of the original amount, since it is used as cow feed but it's not as efficient as fresh grass.
  The mineral concentrate was credited with potassium chloride because potassium is its main component.
  The fructo-oligo-saccharides (FOS) was credited with sugar from sugar beet, with a ratio of 1 to 0,5, since it can partly replace sugar in the market.
- It was assumed that the soy oil produced in the soy treatment is fully replacing palm oil in the market.
- The truck payload is 17.3 ton.
- The average transport distance of both natural and cultivated grass from the location it is clipped to the Grassa biorefinery was set at 10 km.
- The average transport distance of soy is set at 9000 km since the majority of soy in the Netherlands is imported from South America. The type of transport in this case is a container ship, ocean going, with an average payload of 5000 ton.

3. Results

The comparative results presented as ReCiPe endpoint environmental impact categories are shown in table 1. Endpoints are deduced from the more elaborate midpoints (Appendix 1). Although midpoint indicators give more elaborate information, they are also more difficult to interpret. This is why endpoints are presented here to give an overview of the results.
Checks on sensitivity of outcomes towards (assumed) data were performed. The outcome was that there are no immediate reasons to doubt the outcome of the performed LCA.
It should be taken into account that all outcomes are related to the functional unit, chicken feed with the same raw protein content, and reference flow of 30 kg of grass meal compared to 32.25 kg of soy meal.

Table 1: Comparative assessment at endpoints area of protection, per functional unit

Endpoint environmental impact	**Grass meal**	**Soy meal**
Damage to human health (DALY)	5.45E-07	7.2 E-05
Damage to ecosystems (species × year)	1.06E-09	1.3 E-07
Damage to resource availability ($)	-2.56E-01	1.7 E+00

The main contribution to all of the results for soy meal is the soy treatment itself. It involves the use of cyclohexane which is obtained by distillation of oil, but since the data that was used for the soy meal production comes from a pre-made GaBi process, it is not possible to provide specific information about which part of the product system has the biggest impact for this scenario. Also transport influences the results, even with the subtraction of environmental impacts due to avoiding the production of palm oil.

The process that appears to be most impactful as regards the Grassa production chain of grass meal is the cultivation of switchgrass. This means that if the percentage of cultivated grass could be reduced and replaced with an increased percentage of natural grass, the results could be further improved (so less impact).

Damage to human health

From the results , it appears that obtaining proteins from soy causes more than 100 times as much impact regarding damage to human health in comparison with obtaining proteins out of grass.

Damage to ecosystem

Concerning the damage to ecosystems, the impact given by grass protein is also more than 100 times lower compared to the impact given by soy protein.

Damage to resource availability

In the case of the damage made to resource availability and the extra costs involved for future mineral and fossil resource extraction, the soy meal scenario also seems to produce a higher damage.

The results from table 1 were normalized in order to give an indication about the order of magnitude of the outcomes. Normalization is a translation step in which the outcomes of table 1 are set as a percentage in relation to the average damage caused by one European person per year. The value is still related to the functional unit and used reference flow. Table 2 is showing these normalized results.

Table 2: Normalized endpoints

Endpoint environmental impact	Grass protein	Soy protein
Damage to human health	0.003%	0.356%
Damage to ecosystems	0.001%	0.072%
Damage to resource availability	- 0.083%	0.556%

Table 2 shows for example that for the category damage to human health, 30 kg grass meal produces 0.003% of the impact of what one European person on average would have throughout a year. For soy protein, this value equals 0.356% for the same impact category. Same thing could be concluded for the negative impacts, so for example in the damage to resources availability, proteins from grass saves 0.083% of the impact that one European person on average would have throughout a year, while soy protein produces 0.556% of the same impact.

In table 3, the results from table 2 are presented in a different way. The highest impact from table 2 was converted to a value of 100. The other impacts were multiplied with the same conversion factor (relative scaling). This way the relative effects between the six environmental endpoint impact values are given on a scale from 0 to 100. The results shown in table 3 are also the results used for the infographic (Appendix 2) which is created from the LCA (in Dutch).

Table 3: Relative effects

Endpoint environmental impact	Grass Protein	Soy protein
Damage to human health	0.5	64.1
Damage to ecosystems	0.1	13.0
Damage to resource availability	-15.0	100.0

4. Conclusions

The purpose of this study was to assess the environmental impacts of protein from grass that is used for chicken feed and compare them with the impacts of protein used for chicken feed from a conventional source, soy. This comparison was conducted by means of a consequential LCA. All conclusions are only valid for the specific scenario modelled in this study.

The results of the LCAs clearly show a lower environmental impact for the grass protein scenario compared to the soy protein scenario. As mentioned in the assumptions, for both scenarios each by-product was credited, to have a fair comparison.

It is quite likely, but not guaranteed, that the environmental effects of grass protein will decrease when the biorefinery will only be fed with natural grass instead of a mixture of cultivated and natural grass.

References

1. National Institute for Public Health and the Environment (RIVM). *LCIA: the ReCiPe model.* [Online] National Institute for Public Health and the Environment (RIVM). [Citaat van: 16 March 2020.] www.rivm.nl/en/life-cycle-assessment-lca/recipe.

2. De Giacomi, Claudio. *Graswärmedämmung Gramitherm Ökologische Begutachtung und Transferkonzept (confidential).* sl : ZÜRCHER HOCHSCHULE FÜR ANGEWANDTE WISSENSCHAFTEN DEPARTEMENT LIFE SCIENCES UND FACILITY MANAGEMENT INSTITUT UNR, 2014.

Appendix 1: Midpoint environmental impacts

Table 4: Comparative results per midpoint environmental impact category

Midpoint Impact categories	Comparative results	
	SOY	GRASS
Climate change, excl biogenic carbon [kg CO2 eq.]	1.43E+01	-1.77E-01
Climate change, incl biogenic carbon [kg CO2 eq.]	-3.37E+01	-3.67E+01
Fine Particulate Matter Formation [kg PM2.5 eq.]	4.27E-02	1.55E-03
Fossil depletion [kg oil eq.]	4.28E+00	-2.29E-01
Freshwater Consumption [m3]	1.34E+01	-5.05E-02
Freshwater ecotoxicity [kg 1,4 DB eq.]	1.41E-03	4.57E-04
Freshwater Eutrophication [kg P eq.]	1.14E-02	8.20E-05
Human toxicity, cancer [kg 1,4-DB eq.]	1.05E-02	3.10E-03
Human toxicity, non-cancer [kg 1,4-DB eq.]	-4.82E+01	-3.27E-01
Ionizing Radiation [Bq C-60 eq. to air]	5.66E-02	-1.96E-02
Land use [Annual crop eq.·y]	1.19E+02	9.56E+01
Marine ecotoxicity [kg 1,4-DB eq.]	6.03E-03	6.24E-04
Marine Eutrophication [kg N eq.]	7.06E-02	4.40E-04
Metal depletion [kg Cu eq.]	3.16E+00	-6.07E-04
Photochem. Ozone Form, Ecosystems [kg NOx eq.]	1.42E-01	5.05E-03
Photochem. Ozone Form, Hum. Health [kg NOx eq.]	1.41E-01	5.02E-03
Stratospheric Ozone Depletion [kg CFC-11 eq.]	1.86E-04	4.11E-06
Terrestrial Acidification [kg SO2 eq.]	1.33E-01	5.53E-03
Terrestrial ecotoxicity [kg 1,4-DB eq.]	4.59E-01	2.83E-02

Appendix 2: Infographic

Figure 3: Infographic