Carbon footprint assessment of Delfos (DCP)

Darling Ingredients

blonk consultants

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Title	Carbon footprint assessment of Delfos (DCP)	
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1. Introduction

This report contains the results of a carbon footprint assessment[1] of Delfos (dicalcium phosphate products as produced by Darling Ingredients) and an explorative comparison with monocalcium phosphate obtained from mined rock phosphate. The study was commissioned by Darling Ingredients and performed by Blonk Consultants in line with state of the art carbon footprint methodology using most recent available standards.

Darling Ingredients produces dicalcium phosphate under the tradename Delfos. Delfos or DCP is used as animal feed additive or organic fertilizer. Primary use for monocalcium phosphate from rock phosphate is fertilizer production for which also phosphoric acid, another product derived from rock phosphate, is used. Monocalcium phosphate is also used as an animal feed additive.

Chapter 2 of this report describes the goal and scope of the study and the applied methods. The sources of greenhouse gas emissions in the supply chain of the product are shown graphically for Delfos in Chapter 3. The average carbon footprint is also presented in Chapter 3. In Chapter 4, the carbon footprint of Delfos is compared with the carbon footprint of monocalcium phosphate sourced from mined rock phosphate.

[1] A carbon footprint of a product is the sum of all greenhouse gas emissions in the production chain that can be attributed to the product.

2. Goal, scope and methods

2.1 Goal and scope of the study

The goal of the study is to give insight in:

- the carbon footprint Delfos (DCP) produced by Rousselot;
- the contributions of different sources to the carbon footprint;
- a preliminary comparison with mineral monocalcium phosphate (MCP) produced for Western Europe.

The calculated carbon footprint in this case is based on a partial lifecycle assessment (also known as cradle-to-gate assessment). Transport of Delfos, optional further processing and the consumption phase are not included. The carbon footprint of Delfos is calculated as an average over the production in 2014 and 2016.

2.2 Calculation method

For this study, the most recent insights on assessing the carbon footprint of animal products and animal by-products were used in combination with the currently available specifications. The carbon footprint of Darling Ingredients products is assessed according to TS14067 (ISO 2013), which is a further specification on the ISO standards for lifecycle assessments (ISO 14040/44). Upstream greenhouse gas emissions are allocated to co-products based on their economic value at the slaughterhouse exit. Land use change (LUC) related emissions are included but also separately reported when relevant. The calculations of these emissions are based on the Land Use Change Assessment Tool (Blonk Consultants 2014), which is recommended as tool in the PEF methodology of the EC.

The carbon footprint of upstream emissions from husbandry are taken from the Agri-footprint 2.0 database[2] (Blonk Agri-footprint BV 2015a, 2015b), developed by Blonk Consultants. Allocation at the slaughterhouse is based on primary data supplied by Darling Ingredients. The rendering process data to upgrade the slaughterhouse by-products into marketable goods is also provided by Darling Ingredients and it is specific to the relevant plant where production is taking place. The carbon footprint of the rendering process is allocated to the co-products based on their economic value as ex-works at the slaughterhouse (i.e. economic allocation is used).

The results of the carbon footprint concern multiple year averages and are presented with a breakdown to life cycle stages contribution.

[2] Agri-footprint is a high quality and comprehensive life cycle inventory (LCI) database, focused on the agriculture and food sector. It covers data on agricultural products: feed, food and biomass and is used by life cycle assessment (LCA) practitioners. In total the database contains approximately 5,000 products and processes.

3. Production chain descriptions and carbon footprint

3.1 Production chain of Delfos

Food grade bone chips of either porcine or bovine origin as well as dry ossein (porcine) are used as inputs to the production process. Both bone chips and ossein are products of bone degreasing. Porcine and bovine bones ex-work prices, at the slaughterhouse exit, are provided by Darling Ingredients. Bovine bones have a zero price at the slaughterhouse exit, so there is no carbon footprint of husbandry allocated to them.

Delfos is in fact a by-product of the gelatine production process, produced in a three times bigger volume than the gelatine output. Allocation is based on economic revenues from the two products, leading to an allocation factor of approx. 12% for the Delfos. The rest is allocated to gelatine.

The carbon footprint of Delfos includes:

a) Production and transport of animal raw materials (bovine and pig bones);
b) Production, transport and combustion of fuels and chemicals in the Delfos production process

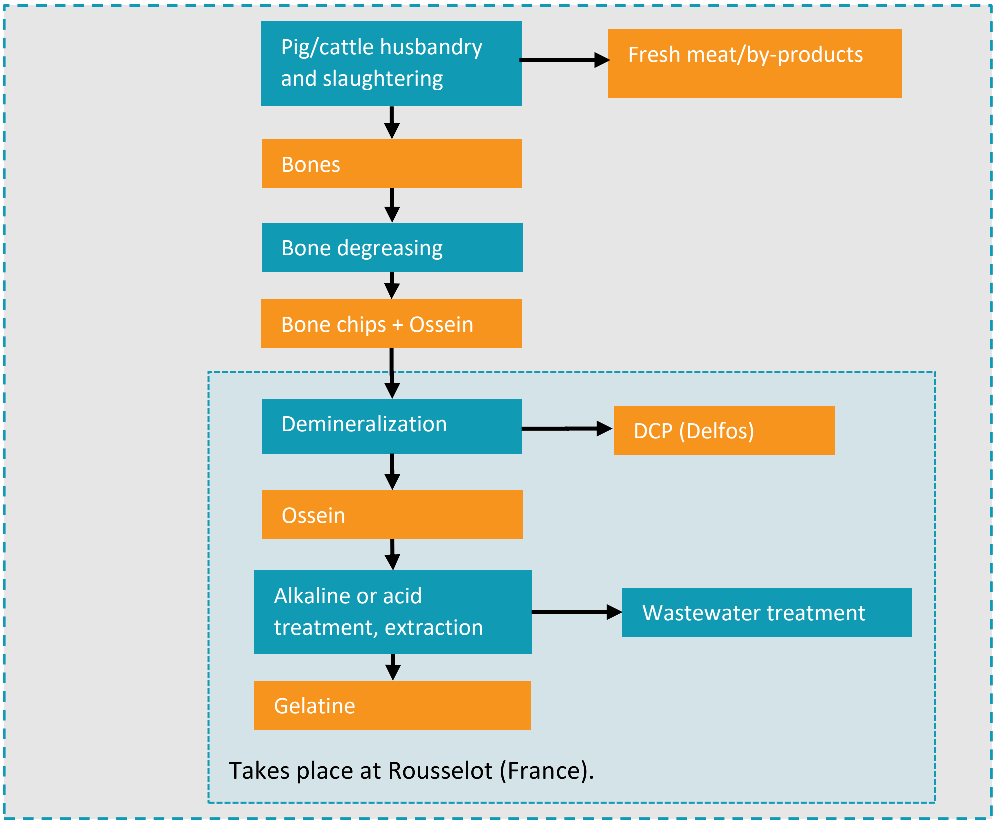

Figure 1 Schematic production chain of DCP (Delfos) at Rousselot. (orange boxes are products and blue boxes are processes)[3]

[3] The husbandry has no impact to the production of Delfos. The economic price of bones leaving the slaughterhouse are zero so no impact is allocated to the upstream processes.

3.2 Carbon footprint of Delfos

The carbon footprint of Delfos was 134, 137 and 108 kg CO_2eq per ton in 2016, 2015 and 2014 respectively (Figure 2). The multi-year (2014-2016) rounded average carbon footprint of Delfos is 126 kg CO_2eq per ton. In 2014 the Delfos price dropped slightly which is also reflected by a smaller carbon footprint in that year. The carbon footprint is evenly distributed among the processing of bone chips and ossein (i.e. food grade material input), the transportation of the input material to the rendering facility and the chemicals used in the production process.

In line with ISO/TS 14067, the impact due to land use change should be reported separately. In the case of Delfos production the impact associated with land use change is solely due to porcine material, since the food grade bovine bones have zero value at the slaughterhouse exit. The land use change impact is relatively small, representing 2% of the total carbon footprint.

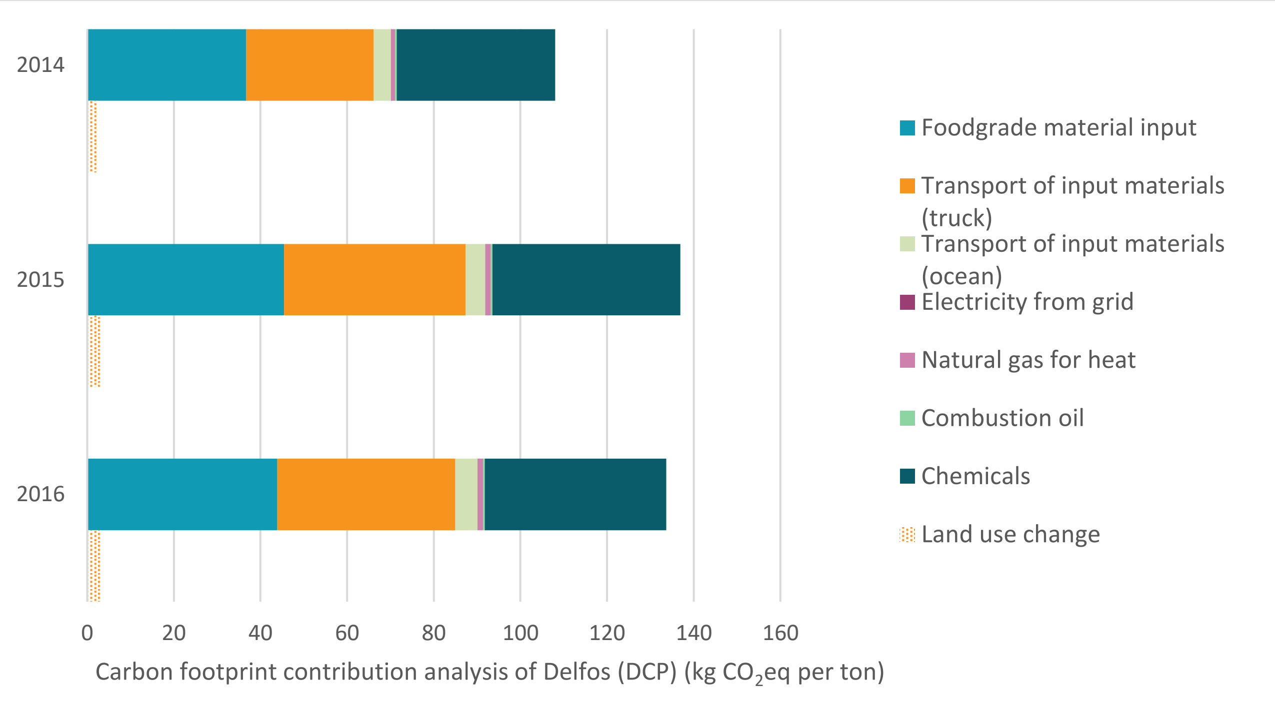

Figure 2 Carbon footprint contribution analysis of Delfos (DCP)

4. Comparing DCP carbon footprint with monocalcium phosphate

4.1 Monocalcium phosphate (MCP) as an alternative

In this section, we aim to compare Delfos to mineral monocalcium phosphate (MCP) produced from rock phosphate. The latter is used both as a feed additive as well as for fertilizer application. As a fertilizer, it is usually denoted as triple superphosphate. Although the production process might differ for MCP produced for different applications, the composition is in both cases mainly pure MCP in the form of the monohydrate, $Ca(H_2PO_4)_2{\cdot}H_2O$. As the most authoritative literature is based on the production of triple superphosphate in Western Europe, this production route will be used as the basis for comparison. The production route involves rock phosphate and phosphoric acid imported from regions outside of Western Europe. Table 1 shows the inventory of triple superphosphate production as taken from Agri-footprint.

Table 1 Life Cycle Inventory of triple superphosphate (taken from Agri-footprint)

Known outputs to technosphere. Products and co-products.	**Amount**	**Unit**	**Comment**
Triple superphosphate, as 80% Ca(H2PO4)2 (NPK 0-48-0), at plant/RER Economic	1000	kg	Remainder is water
Known inputs from technosphere (materials/fuels)	**Amount**	**Unit**	**Comment**
Phosphate rock (32% P2O5, 50% CaO) (NPK 0-32-0)/RER Economic	450	kg	30% P2O5 from rock
Phosphoric acid, merchant grade (75% H3PO4) (NPK 0-54-0), at plant/RER Economic[4]	622	kg	70% from acid
Process steam from natural gas, heat plant, consumption mix, at plant, MJ EU-27 S System - Copied from ELCD	2	GJ	energy used in drying, powder production and granulation
Process water, ion exchange, production mix, at plant, from surface water RER S System - Copied from ELCD	110	kg	dilution of acid
Transport, sea ship, 60000 DWT, 100%LF, short, default/GLO Economic	1665	tkm	transport of phosphate rock from western Sahara to port in Europe
Transport, freight train, electricity, bulk, 100%LF, flat terrain, empty return/GLO Economic	135	tkm	transport of phosphate rock from port to phosphoric acid production plant
Emissions to air	**Amount**	**Unit**	**Comment**
Water	182	kg	vapour released during drying

In Figure 3, the contribution of energy and raw materials input to the total carbon footprint of triple superphosphate is shown. The total carbon footprint is 565 kg CO_2 eq. per ton.

[4] The process "phosphoric acid, merchant grade, at plant" includes both production data and transportation, with transportation accounting for approx. 6% of the impact.

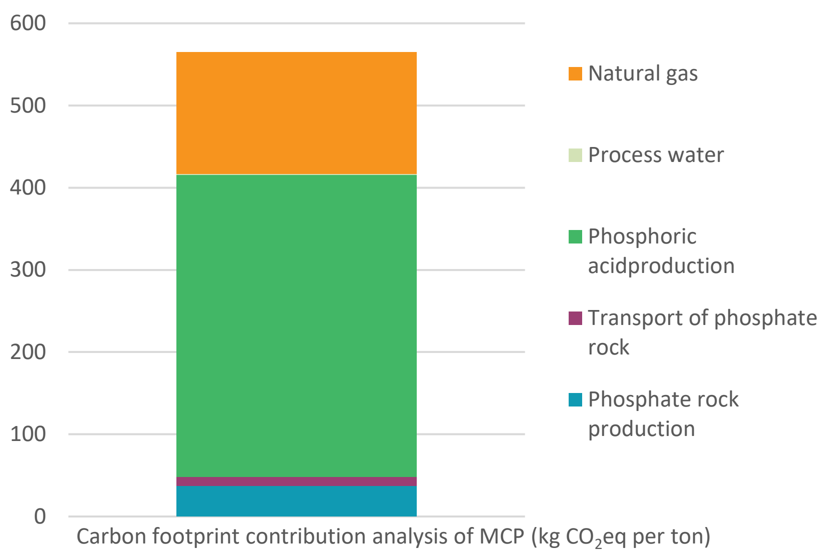

Figure 3 Carbon footprint contribution analysis of MCP (taken from Agri-footprint)

4.2 Comparison of Delfos with MCP

The carbon footprint of one ton of MCP has been determined at 565 kg CO2eq/ton. In Figure 4, the carbon footprint of MCP (as triple superphosphate) is compared to this of Delfos. Delfos has approx. 80% lower carbon footprint.

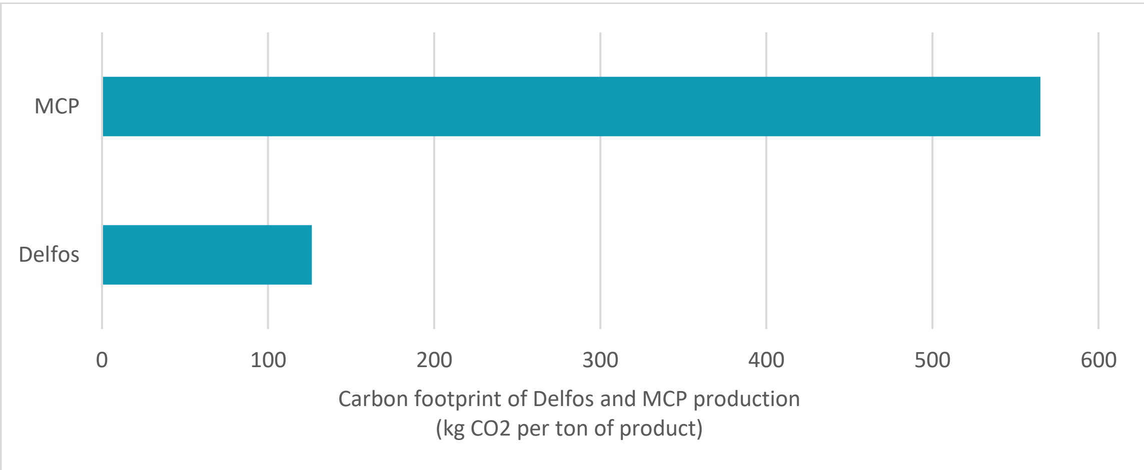

Figure 4 Carbon footprint of Delfos and monocalcium phosphate (MCP) production in kg CO_2 eq. per ton of product

For further comparing the products, it was decided to focus on some functionality criteria; 1) a digestibility factor for feed (pigs), 2) an absorbability factor for feed (poultry) and 3) a solubility factor based on the solubility of phosphor in neutral ammonium citrate for the application as fertilizer. These factors are gathered in Table 2 (feed) and Table 3 (fertilizer) and are based on literature sources and information from Darling Ingredients on the properties of Delfos.

Table 2 Digestibility and absorbability factors for Delfos and MCP

	P content (g/kg)	Digestibility of P for pigs (%)	Digestible P for pigs (g/kg)	Absorbability of P for poultry (%)	Absorbable P for poultry (g/kg)
Delfos	172	0.79	136	0.79	136
MCP	209[5]	0.82	171[6]	0.81	169[7]

Table 3 Solubility factors (in neutral ammonium citrate) for Delfos and MCP

	P content (g/kg)	Solubility of P (%)	Soluble P (g/kg)
Delfos	172	0.75	129.0
MCP	209	0.98	204.8

Table 4, as well as Figures 4, 5, 6 and 7 describe the carbon footprints of Delfos and MCP products in terms of the digestibility and absorbability factors described in Table 2 and the solubility factors described in Table 3. In all cases Delfos has a lower impact than the alternative MCP.

Table 4 Carbon footprint of Delfos and MCP based on different functionality criteria

	kg CO2eq/kg product	kg CO2eq/kg digestible P for pigs	kg CO2eq/kg absorbable P for poultry	kg CO2eq/kg soluble P
Delfos	0.12	0.91	0.91	0.96
MCP	0.57	3.30	3.34	2.76

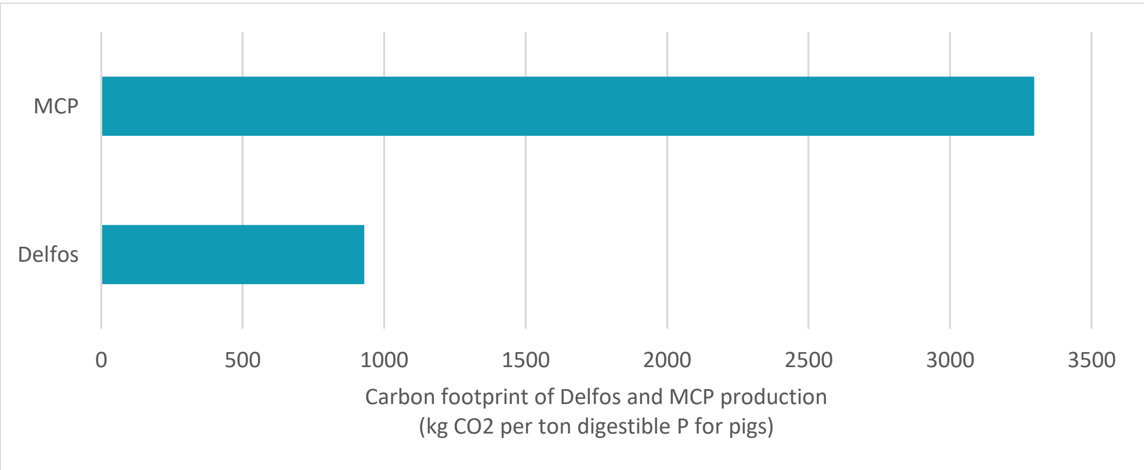

Figure 5 Carbon footprint of Delfos and monocalcium phosphate (MCP) production in kg CO_2 eq. per ton of digestible P for pigs

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[5] Phosphor content may vary depending on production and purity, the value applied is that on which the environmental data in (Davis and Haglund 1999)is based.
[6] Based on 82% uptake of P (Jongbloed and Kemme 2002)
[7] Based on 81% absorbability of P in broilers (Group 2007)

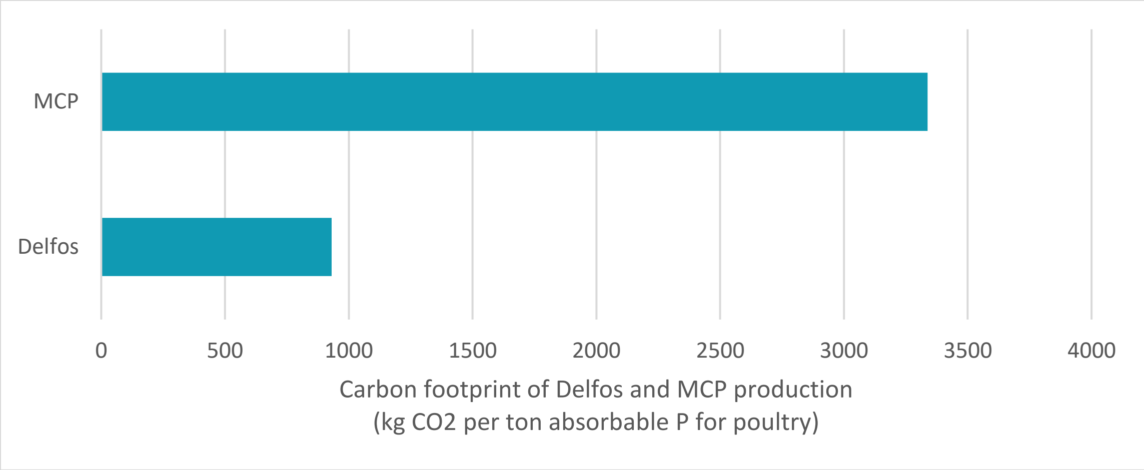

Figure 6 Carbon footprint of Delfos and monocalcium phosphate (MCP) production in kg CO_2 eq. per ton of absorbable P for poultry

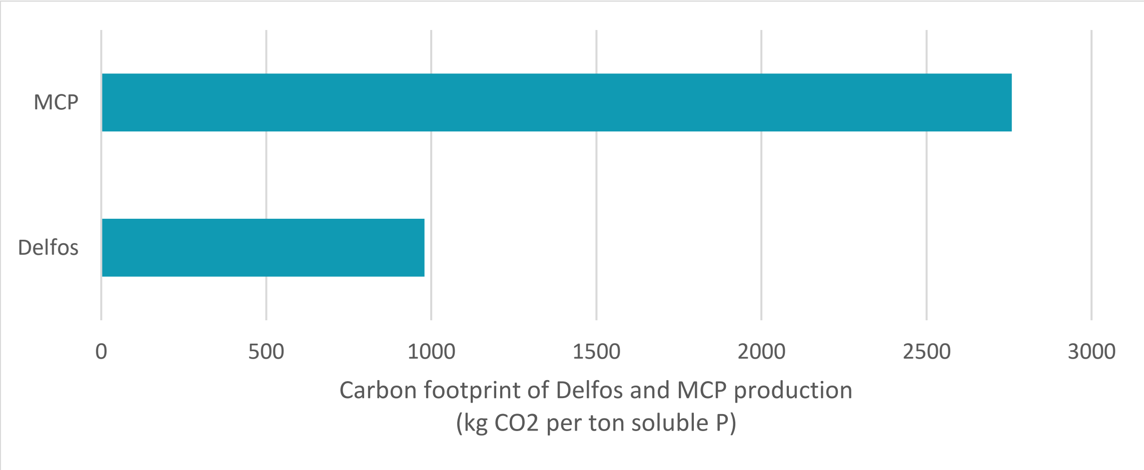

Figure 7 Carbon footprint of Delfos and monocalcium phosphate (MCP) production in kg CO_2 eq. per ton of soluble P

4.3 Concluding remarks

Overall, we conclude that Delfos has less impact on global warming than the production of monocalcium phosphate (MCP) not only on a weight basis but also in terms of functionality such as phosphorus digestibility, absorbability and solubility. Of course, it should be noted that the production of Delfos is “benefitted” by allocating the highest impact to gelatine production based on relative revenues. The prices of the products and the related revenue division to the co-products might change in the future.

Regarding the data quality, it must be noted that, the processing data of Darling Ingredients is of good quality as it is accurate information based on actual measurements in the plant. However, the impact of the chemicals is based on background datasets, where the quality is considerably lower. For instance, the production of certain chemicals, such as hydrochloric acid (HCl), might follow different production routes with different environmental profiles each. However, the main conclusion still would remain the same and Delfos would have a smaller carbon footprint that the MCP.

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