How to allocate the environmental impact between co-products ? Discussion on the case of dairy protein fractionation process

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Discussion on the case of dairy protein fractionation process

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Issues

Food contributes to 24% of the overall carbon footprint in France and the dairy sector itself is 6%. While farming takes 70-90% of food's environmental impacts, processing is the stage where raw goods are often divided into several co-products, each with specific technological itineraries. Allocating the impacts of agriculture and of processing operations to the co-products is important for the fair evaluation of food by life cycle assessment (LCA).

Case study and approach

The milk protein α-lactalbumin is valuable in infant formula to adapt cow milk to human babies. It is isolated from whey as a result of a cascade of separation operations, from skimming to various membrane separations (Fig. 1). The gate-to-gate life cycle inventory was found in Gesan-Guiziou et al. (2019, doi: 10.1016/j.seppur.2019.05.008). The mass, dry matter, protein or economic allocations were applied homogeneously at every subdivision step. The environmental impacts were calculated for the quantity of each coproduct generated during 1 day of plant operation as the functional unit, using the SimaPro 9.4 LCA software, the EF 3.0 method and the Agribalyse 3.0 and EcoInvent 3.8 databases. For each type of allocation, the results were compared to the mass, dry matter, protein or economic balance of the products, as if the plant was regarded as a black box.

Impacts allocation	to skim milk	to cream
mass	89%	11%
dry matter	68%	32%
protein	92%	8%
economic	50%	50%

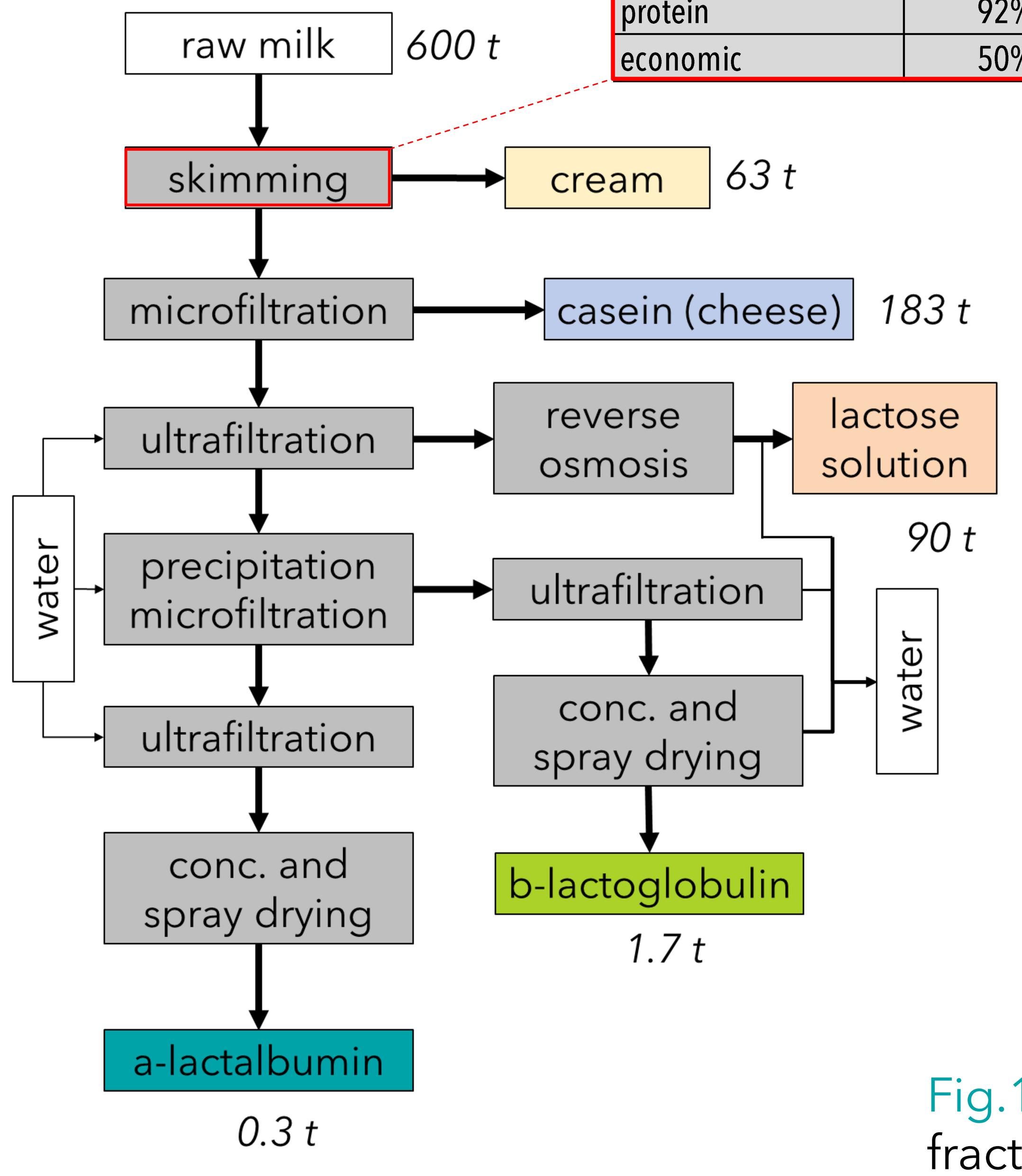

Fig.1A: **Detailed itineraries with explicit subdivisions**

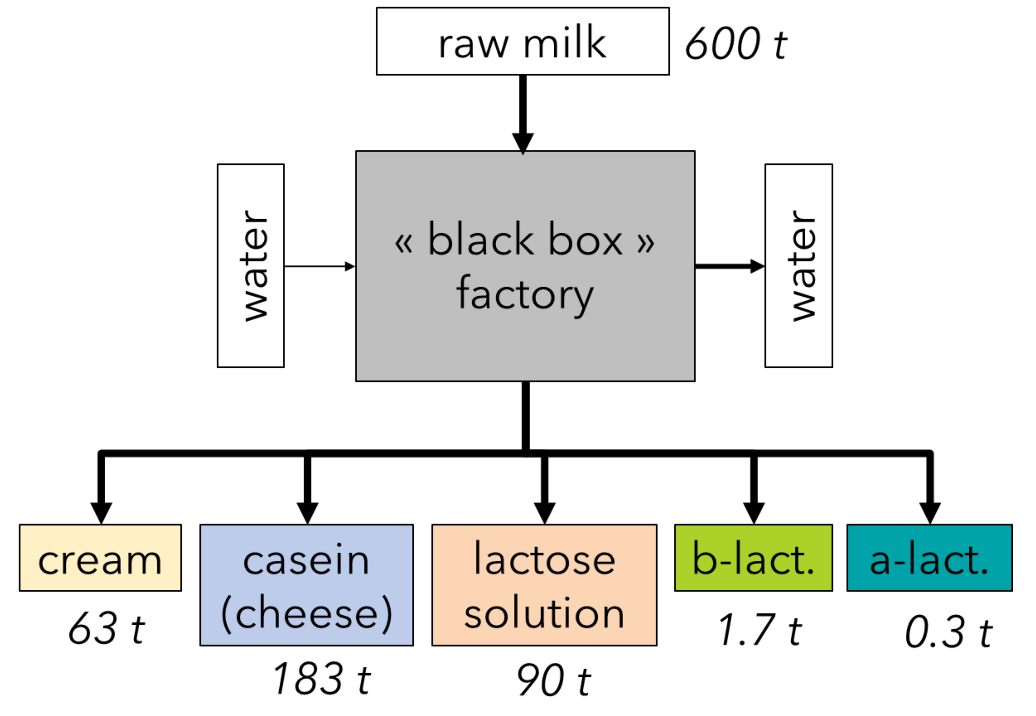

Fig.1B: **Black box**

Fig.1: System perimeter for 1-day of dairy protein fractionation. In (A), each product receives the impacts of its respective itinerary and allocation is calculated and applied at each subdivision (see example at the skimming stage). In (B), each product receives a share of the overall plant's impacts and allocation is applied globally.

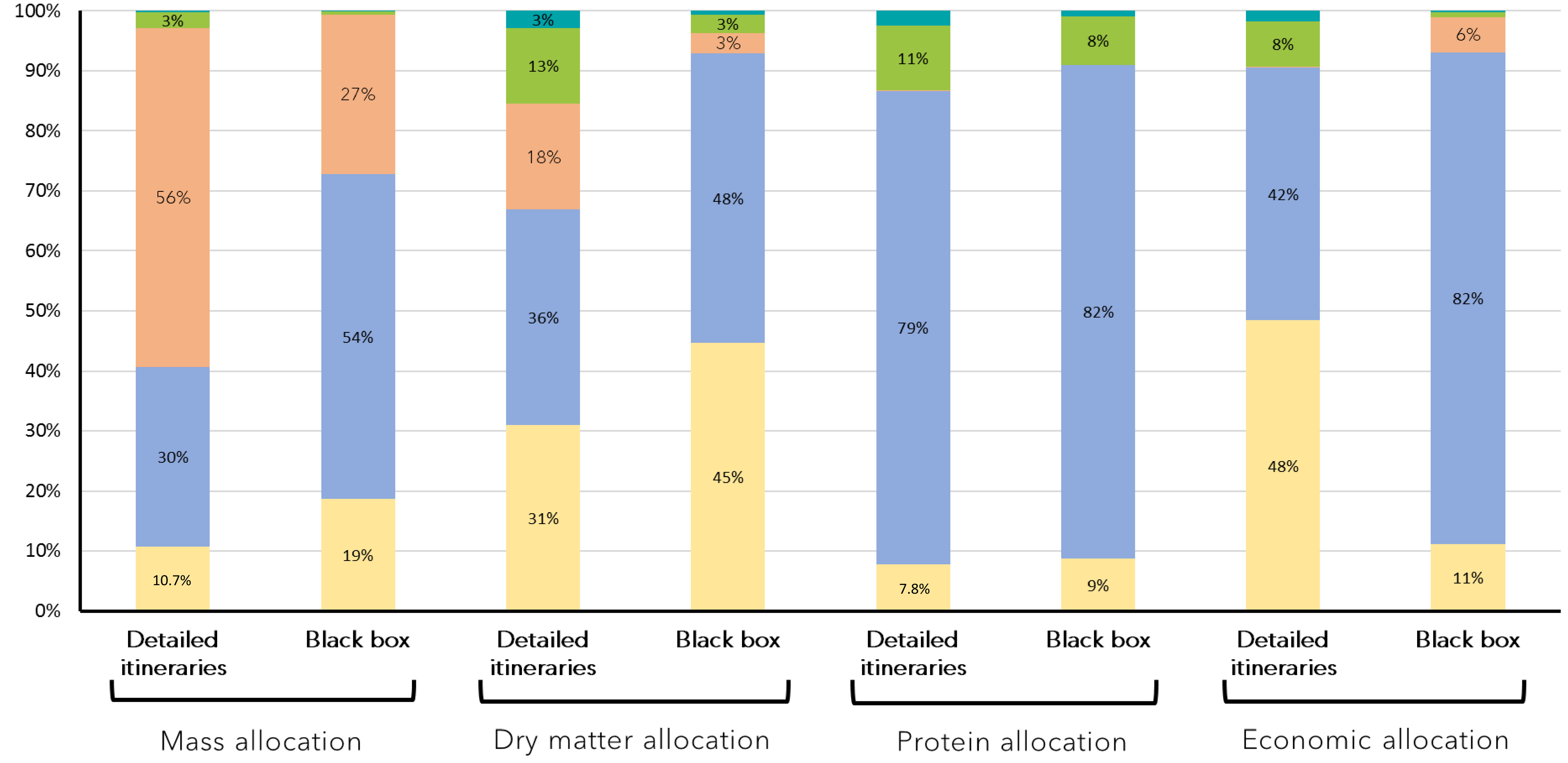

Fig.2: Respective contributions of the cream (■), casein retentate (■), lactose (■), β-lactoglobulin (■) and α-lactalbumin (■) to the overall impact of 1-day plant operation on climate change, depending on the chosen allocation and whether or not the specific technological itineraries of each product flow are considered.

Findings

- Allocation makes a difference and requires collective sectorial choice to allow comparison between plants;
- In particular, allocation has an important consequence in terms of calculated environmental impact of industrially valuable co-products, e.g. it can be 0 for lactose;
- Subdivisions must be considered to avoid irrelevant allocation, e.g. of spray-drying's impacts onto cream;
- When calculating the impacts of 1 kg α-lactalbumin, spray-drying and cleaning are the most impacting operations (not shown).

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