Co-products from meat processing: the allocation issue

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ABSTRACT

Allocation of the environmental burdens to the co-products generated in the meat processing sector is a methodological issue. A study was undertaken on six animal species (beef, veal, lamb, kid goat, pork, broiler) to identify the co-products generated at slaughtering and cutting stages. The status (waste or co-product) and destination of each co-product were defined. Their masses as well as their physical composition (dry matter, protein, fat and energy contents) were quantified. A sensitivity analysis was performed on seven kinds of allocation rules in order to propose the most appropriate for the meat sector: mass, dry matter content, energy, protein, fat content, a combination of the fat and protein contents, and the economic value. This led us to propose the allocation on the basis of dry matter, which corresponds to the content in fat and protein, and consequently is appropriate to reflect all the co-products functions.

Keywords: animal co-products, meat processing, allocation, life cycle assessment

1. Introduction

The environmental impact assessment of the food products through Life Cycle Assessment is a matter under development and some methodological issues are still discussed. The allocation of burdens between the various co-products of the animal after slaughtering (edible products, bone, offal not intended for human consumption, skins, etc.) is a tricky point. These products may represent until 60 % of the animal live weight and are raw materials for several economic sectors downstream (gelatine, leather, pet food, fertilization, etc.).

International guidelines and standards can help to handle this question. ISO (2006) suggests that allocation should be avoided as far as the system allows it, by (1) subdivision of the multifunctional process in sub-processes, or (2) system expansion to include the functions of the co-products. Then when allocation can't be avoided, an allocation rule based on (4) physical causality linked to the function of the co-products must be preferred to (5) other relationships, such as economic value; (6) several of these options can be mixed. PAS 2050 (2008) follows partly the ISO standard but recommends economic allocation as the third step, if sub-division and system expansion are not feasible. The recent draft guidelines provided by the LEAP initiative, in particular on animal feed (LEAP 2014), suggest the same hierarchy as ISO and introduce a new notion: co-products are waste, residues (marginal price) or "real" co-products. Those standards recommend doing a sensitivity analysis if several allocation procedures are applicable. Most of the LCA studies identified use economic allocation (Bengtsson et al. 2012, Joseph and Nithya 2009, Notarnicola et al. 2011), at least between groups of meat co-products having the same type of usages and market. One limit of the economic allocation is that the market value of some Animal By-Products (APB) does not reflect their subsequent usage. As a consequence of animal crises in the two last decades, the ABP market prices drastically collapsed, while they still are used. Other authors also explored other possibilities. Katajajuuri et al (2008) applied an allocation on the meat-mass of the chicken co-products; Schmidt et al. (2010) for meat, and Clarke (2012) for leather prefer system expansion if possible; Bier et al. (2012) in a study on blood conclude that both allocate on mass and consider blood as waste are appropriate. The dairy industry is probably the food sector in which the issue of allocation has been studied the most. The International Dairy Federation (IDF 2010) recommends allocating raw milk and transportation on the basis of the milk solids of the final products and to allocate other inputs and emissions using a physico-chemical allocation matrix (proposed by Feitz et al. 2007). At French level, in the perspective of environmental labeling, the dairy sector has proposed to use a physical allocation based on the content of dry matter (milk solids) of the products (CNIEL and Quantis, 2012).

Then, a study was undertaken to analyze the issue of allocation for meat co-products considering six animal species: beef, veal, lamb, kid goat, pork and broiler. It aimed to better define meat co-products, explore several allocation procedures and provide recommendations for the meat sector.

2. Materials and methods

2.1. Scope of the study

The study concerns slaughtering and cutting stages in the meat processing sector, considering six animal species: beef, veal, lamb, kid goat, pork and broiler.

2.2. Status and composition of the meat co-products

The co-products generated are Edible co-products and Animal By-Product (ABP) among which ABP of C1, C2 and C3 categories are distinguished referring to the European regulation on waste (CE/1069/2009). These ABP are components presenting sanitary risks relating to conventional agents (C2) and to bovine spongiform encephalopathy (C1), proteins (PAP) C3 and fat C3, bones C3 processed in gelatine, raw fat processed into fat and "cretons", raw skins used in tannery and organic matter used for land-spreading, composting or biogas production.

Each material was also defined as a co-product or a waste, following the recommendations of the European directive on waste (CE/98/2008). Following this regulation, ABP do not have to be considered as waste if they follow the four following criteria: (1) the later use is certain, (2) the by-product can be used without any specific treatment different from usual industrial practices, (3) the by-product is part of the production process, (4) the later use is legal.

Table 1. Co-products from the meat industry and their destination

Co-products	Destination	Direct or after process usage	Status
Meat, offal, blood, fat, rind	Food industry	Human Food	Products
SRM, sanitary seizures, residues from the first waste water treatment	Processing of ABP C1-C2 in MBM and Fat	Cement works (MBM C1), fertilizing (MBM C2), Biodiesel (Fat C1-C2)	Waste
Other meat, offal, blood, fat, rind	Processing of ABP C3 in PAP C3 and Fat C3	Pet Food, Animal Food	Products
Bones, tendons	Processing of bones C3 in gelatine	Edible gelatine; fertilizing meal	Products
Tallow, grease	Processing of raw fat C3 in fat and "cretons"	Lipochemistry, oleochemistry, fertilizers, pet food, animal food	Products
Hide, masks	Tannery	Clothes, shoes, furniture	Products
Digestive tract content, manure, residues from the first waste water treatment	Land spreading, composting, biogas	Organic matter use	Waste

SRM: Sanitary Risk Materials; MBM: Meat and Bone Meal

2.3. Allocation procedures explored and corresponding data collection

Seven kinds of allocation rules were tested, after excluding waste components. Six rules are related to physical causalities: mass, dry matter mass, energy, protein, fat content, a combination of the fat and protein contents. They were chosen to their relevance with the different functions of the meat co-products (providing feed protein, fat and energy). The last rule is the economic allocation.

To describe the slaughtering and cutting processes and the composition of the co-products obtained at each stage, a survey has been performed on 16 French plants. Additional data from literature were used to complete the data set. For each of the seven destinations identified, the mass of co-products (Table 2) as well as their physical composition (dry matter, protein, fat and energy contents) and price were quantified.

System expansion was also explored. The aim was to define a substitution scenario for each co-product and each destination. It was not always possible to define clear and objective hypothesis, as shown in Table 3, and to collect corresponding LCA data. In consequence, this way of handling co-products is not presented in this paper.

Table 2. Part of the animal live-weight (in %) to the different co-products destinations for 6 animal species (primary data from 16 processing plants in France)

Destination	Culled cow	Veal	Lamb	Kid goat	Pork	Broiler
Food industry	45%	56%	44%	44%	70%	43%
Processing of ABP C1-C2 in MBM and Fat	10%	9%	2%	2%	5%	6%
Processing of ABP C3 in PAP C3 and Fat C3	7%	6%	13%	13%	5%	51%
Processing of bones C3 in gelatine	8%	6%	3%	3%	9%	0%
Processing of raw fat C3 in fat and "cretons"	13%	6%	6%	6%	4%	0%
Tannery	6%	7%	14%	14%	0%	0%
Land spreading, composting, biogas	10%	9%	17%	17%	7%	0%
Losses	1%	1%	1%	1%	1%	0%
TOTAL	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Table 3. Substitution scenarios for each destination of meat co-product

Destination	Final use	Function indicator	Substitution scenario
Food industry			
Processing of ABP C1-C2 in MBM and Fat	Heat	Lower calorific value	French mix heat
Processing of ABP C3 in PAP C3 and Fat C3	Mainly pet food and animal food	fat and protein content	Other sources of fat and protein; animal or plant origin
Processing of bones C3 in gelatine	Human and animal food Fertilizer industry	Gelatine power N, P	Vegetal gelatine (algae?) Mineral fertilizer
Processing of raw fat C3 in fat and "cretons"	Human and animal food Lipochemistry	Fat content	Plant oil
Tannery	Clothes, shoes, furniture	Area (m^2)	Cotton? Synthetic fabrics ?
Land spreading, composting, biogas	Land spreading, composting, biogas	N, P	Mineral fertilizer

3. Results

Figure 1 presents a selection of the allocation factors obtained with the different allocation rules, those for pork and beef (culled cows and young bulls).

For pork, from about 80% to 100% of the environmental impacts are allocated to co-products intended to human food. The impacts results of those co-products won't vary so much through the allocation procedures tested. This is related to the fact that most of co-products are used for human food industry.

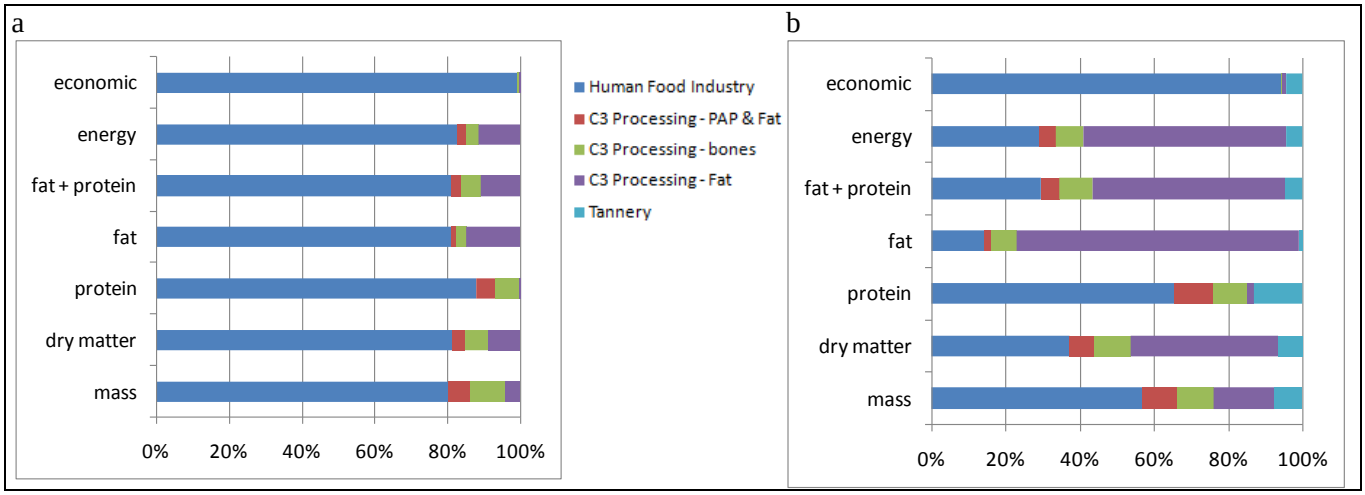

Figure 1: Distribution keys between pork (a) and beef (b) co-products (excluding wastes) according to different allocation rules

Cattle provide a wider range of different kind of co-products. For a given co-product destination, the distribution factors vary a lot from one allocation rule to another. The LCA impact results will be very sensitive to the allocation chosen. About 55% of the co-products (in mass) are valued in the food industry, while hide, bones, fat and other co-products represent a non negligible part. Economic allocation attributes almost 95% of the upstream impact to the human food industry destination and the rest to the hide. None impact is attributed to other co-products despite their downstream use. Fat and protein allocations give very contrasting allocation factors. Energy, fat + protein and dry matter procedures give almost the same allocation factors, as they all represent the interest of main of the co-products and their function in providing protein and fat.

Other species present in-between results, underlining the specificities of each of them: comparing to beef, veal factors are lower for most of the co-products, due to higher carcass yield; the relative part of tannery and C3 – PAP & Fat is higher for lamb, according to the low carcass yield and the grease component for this type of animal; for kid goats, sold as entire carcass, there are less co-products at plant gate, so a higher part is attributed to Human food industry destination; for broiler, every physical allocation procedures give about half of the impacts to human food and half to pet food (PAP & Fat).

4. Discussion

The choice of an allocation procedure should first intend to be meaningful for all co-products regarding their function. In the meat sector, most of the co-products generated are used for their physicochemical characteristics: for their content in protein (human food, pet-food) and/or in fat (gelatine, fats). That pleads for the choice of a physical allocation. A recommendation for the meat sector should be relevant for all animal species. In that way, the allocation on the dry matter content has the following advantages: this criterion combines all of the physico-chemical characteristics of interest (in particular lipids and proteins); it is relevant for the different uses and markets (food, chemistry, leather and for all animal co-products, irrespectively of their destination; it provides stable figures, few dependant of the economical context.

This approach seems appropriate for most of the European countries. Nevertheless, it is now necessary to make sure it could suit in other contexts, where animal by-products could have different status, usages and markets.

System expansion is also probably still a relevant area for future studies even if including functions of the meat co-products has limits.

5. Conclusion

The recommendation of our study is to use an allocation based on the respective dry matter content of each co-product which is relevant to consider all the functions of the co-products in their different uses and markets. It

also has the advantage to be in accordance with the dairy sector. Indeed, the same approach shall be probably preferred for all animal productions from the livestock sector.

Anyway, none of the allocation procedures is perfect and these results underline the fact that a sensitivity analysis should be performed if it can have a great incidence on the impact results, such as carbon footprint. This study provides both primary data on meat processing and helpful figures for sensitivity analysis in LCA in the meat sector.

Further works, such as the actual ACYVIA program in France, would be helpful to go ahead with the allocation issue: dividing in sub processes and perhaps proposing physico-chemical allocation matrix (Feitz et al. 2007) to reflect the underlying relation between resources/impacts and the co-products. This subject should be further explored in the framework of the future Product Environment Footprint European Pilot.

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