Allocation factors for meat coproducts: Dataset to perform life cycle assessment at slaughterhouse

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**ABSTRACT**

The sharing of total environmental impacts between the different products of a multi-output system is crucial in Life Cycle Assessment. ISO standards recommend subdivision then substitution methods when possible. Sometimes, allocations rules are necessary. They consist of allocating the total impact to the different products in proportion to a value that characterize the products. They can be based on physical parameters (such as mass, protein, dry matter, etc.) or the economic value of coproducts can be used as a proxy. As they are based on various type of parameters, allocation rules can lead to significantly different environmental impact results. Then a consensus is difficult to reach between stakeholders as for example in meat sector. To make the debate going further, Chen et al. (2017) proposed a new allocation method based on biophysical parameters (Chen et al., 2017). Adapted from previous methods, they propose to allocate impacts in proportion to the energy needed for the growth, the maintenance and the activity of each tissue. The method has been judged as scientifically viable but also particularly difficult to apply due to the amount of necessary data and to the complexity of the calculation model. In a recent project, we de-
developed a freeware to easily calculate biophysical allocation factors as well as mass and economic factors to allow a fair comparison: MeatPartTool. We also collected data to create a dataset of mass, economic and biophysical allocation factors for a large range of beef (132 individuals), calf (54 individuals) and lamb (14 individuals) at the slaughterhouse stage. This data paper provides both primary data and calculated allocation factors.

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Specifications Table

| Subject                  | Environmental Science – Environmental Impact Assessment |
|--------------------------|--------------------------------------------------------|
| Specific subject area    | Allocation factors for Life Cycle Assessment of meat coproducts |
| Type of data             | Table (raw and calculated data)                        |
| How data were acquired   | - Model input data: grey and scientific literature, expert interviews |
|                         | - Allocation factors: calculated by Chen et al. (2017) models with the MeatPartTool freeware [7] |
| Data format              | Raw Calculated                                        |
| Parameters for data collection | Experts have been solicited to provide and control primary data (i.e. model inputs). Most of them were already validated in other projects. Allocation factors were calculated using a model that have been published and peer-reviewed [1]. |
| Description of data collection | Primary data (i.e. model inputs) were collected during a specific research project. They were provided and discussed by the different partners of the project. Most of them were obtained in the context of previous projects. Some adaptations were necessary to ensure the homogeneity of the present dataset. These modifications are detailed in this paper. Calculated data were obtained by applying the model developed by Chen et al. (2017) for biophysical allocation factors and directly calculated from mass (based on wet-mass) and economic values for mass and economic allocation factors. |
| Data source location     | Institutions: INRAE, IDELE, CELENE, INTERBEV |
|                         | Country: France                                       |
| Data accessibility       | Repository name: Data Inrae |
|                         | Direct URL to raw data: https://doi.org/10.15454/552QFN |
|                         | To access to specific allocation factors: open the raw dataset (https://doi.org/10.15454/552QFN) with MeatPartTool freeware (https://doi.org/10.15454/AIMYFG) |
|                         | Other direct URL to raw data (in French): https://www6.inrae.fr/means/Outils-d-analyse-multicritere/MeatPartTool/Les-bases-de-donnees |

Value of the Data

- These data are useful as they move the debate on allocation factors for LCA of meat forward. There is no consensus between stakeholders on the subject when choosing between allocation methods. The lack of data however makes methods difficult to use and compare. Here is proposed an unprecedented range of mass, economic and biophysical allocation factors for meat coproducts.
- This dataset will benefit to everyone who wants to practice LCA to meat products at slaughter stage. Researchers, industrials, decision-makers are interested to better understand environmental impacts of meat. If they cannot calculate their own allocation factors, they can pick the most appropriate ones in this dataset. Furthermore, by proposing both mass, economic and biophysical allocation factors, the dataset sets political questions aside but offers material to discuss.
• These data can be directly used to allocate environmental impacts between meat coproducts at slaughter stage. The vast range of individuals proposed allows the user to choose appropriate allocation factors instead of generic ones. Furthermore, as both mass, economic and biophysical allocation factors are calculated, the user will be able to easily provide sensitivity analysis when using one or another.

• This dataset offers a large range of mass, economic and biophysical allocation factors that were not available so far in literature. From now, only a few ones existed, mostly generic cases. This is the beginning towards more differentiated datasets appropriated to different realities. The authors think that this dataset should be completed by other individuals, especially from different geographical areas. To help, we developed a freeware that calculates mass, economic and biophysical allocation factors by mixing input data provided by the user and possibly default data if the user miss some.

1. Data Description

1.1. Input data

Primary data (i.e. all the dataset necessary to calculate allocation factors) have been collected from different sources: literature, previous projects and expert interviews. In total, the dataset comprises 132 beef, 54 calves and 14 lambs (Table 1).

For each species, the list of coproducts has been drawn up. For a given species, it is considered that every breed comprises the same coproducts. Each coproduct is then classified by:

| Species | Breeds | Categories | Rearing modes |
|---------|--------|------------|---------------|
| Beef    | Primholstein | Young Bull | Pasture |
|         | Charolaise | Heifer     | Stall |
|         | Limousine  | Cull Cow   | Grazing large area |
|         | Blonde d’Aquitaine | Beef | |
|         | Salers    |            |               |
|         | Rouge des prés |            |               |
|         | Charolaise x Rustique |            |               |
|         | Montbéliarde |            |               |
|         | Normande  |            |               |
|         | Charolaise x Pie Noire |            |               |
|         | Average   |            |               |
| Calves  | Primholstein | Milk-fed veal | Pasture |
|         | Charolaise | Rosé Veal | Stall |
|         | Blonde d’Aquitaine |            | Grazing large area |
|         | Limousine  |            |               |
|         | Normande  |            |               |
|         | Aubrac    |            |               |
|         | Montbéliarde |            |               |
|         | Cow-calf generic |            |               |
|         | Dairy generic |            |               |
|         | Croisé-lait |            |               |
|         | Croisé-viande |            |               |
|         | Average   |            |               |
| Lambs   | Milk-fed heavy lamb | Housed ewes |               |
|         | Milk-fed hardy lamb | Grazing flat pasture |               |
|         | Grass-fed heavy lamb | Grazing hilly pasture |               |
|         | Milk lamb | Housed fattening lambs |               |
|         | Average   |            |               |
- Destination:
  o Human Food
  o Pet Food
  o PAP C3 (animal by-products, blood, etc.)
  o Gelatin C3 (bones, tendons)
  o Skin Tannery C3 (skin, mask)
  o Fat and Greaves C3 (fat, tallow)
  o C1-C2 for disposal
  o Spreading/Compost
- Group of tissues
  o Carcass
  o GIT (stomach, intestines, etc.)
  o Liver
  o Others
  o Whole Body

To complete, in Europe:
- C1 products are those that presents risks of:
  o Spongiform encephalopathy transmission;
  o Presence of residues of toxic substances;
  o Presence of environmental contaminants.
- C2 products are those coming from digestive system that present health hazards
- C3 products are free of risks and used as intrants for industrial production (for example pet-food or fertilizers)

C1 and C2 products are generally discarded.
List of coproducts and associated destinations and groups of tissues for bovine, calf and ovine are respectively available in Tables 2–4. These tables also contain, for each coproduct, the percentages of Water, Dry Matter, Lipids and Proteins. These are the same for every breed of a given species in the present dataset. Those data concerning quantity of coproducts and their physicochemical compositions were compiled by Gac et al. (2012) considering bibliographic references, supplemented by extrapolations and expert estimates when information was lacking.

For each coproduct, the mass fraction of the total mass is necessary. It has been calculated for each breed of each species. They can be considered as generic data to characterize coproducts. Data from Gac et al. (2012) are used as a reference and adapted to each breed depending on carcass yields [2].

\[
BW_{i,j}^\% = \frac{BW_{i,j}^\%_{\text{generic}} \times \frac{\text{Carcass Yield}_j}{\text{Carcass Yield}_{\text{generic}}}}{\text{for carcass coproducts}}
\]

\[
BW_{i,j}^\% = \frac{BW_{i,j}^\%_{\text{generic}} \times \frac{\text{Carcass Yield}_{\text{generic}}}{\text{Carcass Yield}_j}}{\text{for other coproducts}}
\]

with \(BW_{i,j}^\%\) (Empty Body Weight) the mass fraction of the coproduct \(i\) from breed \(j\).

Carcass Yields are available in Tables 5–7. They come from Laisse et al. [3]. These table also contains the Empty Body Weight at slaughter age that differs from a breed to another. These data have been obtained on the basis of a census data extraction operated by Institut de l’Elevage (GES Division) from SPIE (the Professional Livestock Information System approved by the French State), which contains data from the BDNI (National Data Base of Identification which register all animal birth and movements), completed by the Normabev database (concerning slaughter of bovines). This French information system on livestock is described by Delomel and Gibon [4]. When data were not available, mean values have been used.

Next table contains a list of parameters that are identical for each breed of a given species (Table 8). These parameters are used by the model developed by Chen et al. [1] to calculate the
Table 2
Destinations, group of tissues and composition of beef coproducts (from Gac et al. (2012)).

| Co-products         | Destination                | Group of tissues | Water (%) | DRY MATTER (%) | Lipids (%) | Protéins (%) |
|---------------------|----------------------------|------------------|-----------|----------------|------------|--------------|
| Abomasum            | Human food                 | GIT              | 75        | 25             | 5          | 20           |
| Abomasum fat        | Fat and greaves C3         | GIT              | 20        | 80             | 75         | 5            |
| Aponeurosis         | Human food                 | Carcass          | 75        | 25             | 2          | 23           |
| Bile                | PAP C3                     | Others           | 90        | 10             | 2          | 8            |
| Blood               | PAP C3                     | Others           | 80        | 20             | 2          | 18           |
| Blood               | Pet food                   | Others           | 80        | 20             | 2          | 18           |
| Bones               | Gelatin C3                 | Carcass          | 60        | 40             | 15         | 15           |
| Bones of head, brain, eyes and teeth | C1-C2 for disposal | Others           | 62        | 38             | 2          | 30           |
| Cheek               | Human food                 | Others           | 75        | 25             | 3          | 21           |
| Cheek trimmings     | Human food                 | Others           | 75        | 25             | 3          | 21           |
| Chops               | Pet food                   | Others           | 68        | 32             | 2          | 30           |
| Contents of intestines | Spreading/Compost       | GIT              | 85        | 15             | 13         | 2            |
| Contents of therumen | Spreading/Compost       | GIT              | 68        | 32             | 29         | 3            |
| Ears                | PAP C3                     | Others           | 65        | 35             | 10         | 24           |
| Esophagus           | Pet food                   | Others           | 75        | 25             | 4          | 20           |
| Fat                 | Fat and greaves C3         | Carcass          | 10        | 90             | 88         | 2            |
| Fat around heart    | Fat and greaves C3         | Others           | 10        | 90             | 88         | 2            |
| Fat in the kidney   | Fat and greaves C3         | Others           | 10        | 90             | 88         | 2            |
| Feet (without hooves) | Gelatin C3                | Others           | 69        | 31             | 5          | 20           |
| Floatation fat      | Spreading/Compost          | Others           | 15        | 85             | 84         | 1            |
| Forehead            | C1-C2 for disposal         | Others           | 68        | 32             | 2          | 30           |
| Forelock            | PAP C3                     | Others           | 20        | 80             | 0          | 79           |
| Gallbladder         | Pet food                   | Others           | 75        | 25             | 5          | 20           |
| Head trimmings      | Pet food                   | Others           | 75        | 25             | 3          | 21           |
| Heart               | Human food                 | Others           | 75        | 25             | 3          | 20           |
| Heart trimmings     | Pet food                   | Others           | 75        | 25             | 3          | 21           |
| Hide                | Skin tannery C3            | Others           | 68        | 32             | 2          | 30           |
| Hooves              | PAP C3                     | Others           | 20        | 80             | 0          | 79           |
| Horns               | PAP C3                     | Others           | 20        | 80             | 0          | 79           |
| Kidney              | Human food                 | Others           | 75        | 25             | 2          | 21           |
| Large intestine     | C1-C2 for disposal         | GIT              | 75        | 25             | 5          | 20           |
| Liver               | Human food                 | Liver            | 70        | 30             | 5          | 20           |
| Liver trimmings     | Pet food                   | Liver            | 75        | 25             | 3          | 21           |
| Lower jaw           | PAP C3                     | Others           | 60        | 40             | 15         | 15           |
| Lungs               | Pet food                   | Others           | 74        | 26             | 1          | 25           |
| Mask                | Skin tannery C3            | Others           | 68        | 32             | 2          | 30           |
| Mesenteric fat      | C1-C2 for disposal         | GIT              | 10        | 90             | 88         | 2            |
| Muscle              | Human food                 | Carcass          | 76        | 24             | 5          | 20           |
| Muzzle              | Human food                 | Others           | 68        | 32             | 2          | 30           |
| Omasum              | Human food                 | GIT              | 75        | 25             | 5          | 20           |
| Omasum fat          | Fat and greaves C3         | GIT              | 20        | 80             | 75         | 5            |
| Rumen and forestomach | Human food                | GIT              | 75        | 25             | 5          | 20           |
| Rumen fat           | Fat and greaves C3         | GIT              | 10        | 80             | 75         | 5            |
| Sanitary seizures   | C1-C2 for disposal         | Others           | 66        | 34             | 16         | 17           |
| Screening and sifting wastes | C1-C2 for disposal | Others           | 15        | 85             | 84         | 1            |
| Small intestine     | PAP C3                     | GIT              | 75        | 25             | 5          | 20           |
| Spinal cord         | C1-C2 for disposal         | Others           | 75        | 25             | 10         | 10           |
| Spinal cord waste   | C1-C2 for disposal         | Others           | 75        | 25             | 10         | 10           |
| Spine               | C1-C2 for disposal         | Carcass          | 60        | 40             | 15         | 15           |
| Spleen              | Pet food                   | Others           | 75        | 25             | 4          | 21           |
| Stillborn           | PAP C3                     | GIT              | 75        | 25             | 2          | 21           |
| Tallow              | Fat and greaves C3         | Others           | 10        | 90             | 88         | 2            |

(continued on next page)
allocation factors based on the energy required to maintain and produce body tissues as a function of their chemical (protein and lipid) and physiological properties and growth (biophysical allocation). The parameters are:

- Gompertz Coefficient: initial rate of protein growth [5]
- Empty Body Weight at birth (kg) [expert interviews]
- Empty Body Weight at maturity (kg) [expert interviews]
- Birth Body Fat Percentage (%) [expert interviews]
- Normal mature body Fat Percentage (%) [expert interviews]
- Fat percentage at slaughter age (%) [expert interviews]
- Ratio of Body Weight Water to Protein [expert interviews]
- Protein Energy Content (MJ/kg) [5]
- Lipid Energy Content (MJ/kg) [5]

Finally, a coefficient is used to modulate the energy required for the activity. These coefficients are specific for breeds and depend on the rearing mode. Data from IPCC (2006) are used [6]. Data are available in Table 9.

### Table 2 (continued)

| Co-produts       | Destination             | Group of tissues | Water (%) | DRY MATTER (%) | Lipids (%) | Protéins (%) |
|------------------|-------------------------|------------------|-----------|---------------|------------|--------------|
| Tongue           | Human food              | Others           | 72        | 28            | 10         | 16           |
| Tonsil           | C1-C2 for disposal      | Others           | 75        | 25            | 12         | 10           |
| Trachea          | Pet food                | Others           | 65        | 35            | 5          | 29           |
| Udder            | Pet food                | Others           | 86        | 14            | 5          | 3            |
| Upper throat     | Pet food                | Others           | 70        | 30            | 5          | 20           |
| Water in the rumen | Spreading/Compost      | GIT              | 99        | 1             | 0          | 3            |

### Table 3

Destinations, group of tissues and composition of calf coproducts (from Gac et al. (2012)).

| Co-produts       | Destination             | Group of tissues | Water (%) | DRY MATTER (%) | Lipids (%) | Protéins (%) |
|------------------|-------------------------|------------------|-----------|---------------|------------|--------------|
| Abomasum         | Human food              | Others           | 75        | 25            | 5          | 20           |
| Bile             | PAP C3                  | Others           | 90        | 10            | 2          | 8            |
| Blood            | C1-C2 for disposal      | Others           | 80        | 20            | 2          | 18           |
| Bones (11%)      | Gelatin C3              | Carcass          | 65        | 35            | 2          | 25           |
| Dead individuals | C1-C2 for disposal      | Others           | 80        | 20            | 4          | 10           |
| Fat (8%)         | Fat and greaves C3      | Carcass          | 10        | 90            | 88         | 2            |
| Fat from breasts and penis | Fat and greaves C3   | Others           | 10        | 90            | 88         | 2            |
| Feet (without hooves) | Human food             | Others           | 69        | 31            | 5          | 20           |
| Floatation fat   | C1-C2 for disposal      | Others           | 15        | 85            | 84         | 1            |
| Head             | Human food              | Others           | 68        | 32            | 5          | 23           |
| Intestines       | C1-C2 for disposal      | Others           | 75        | 25            | 5          | 20           |
| Kidney           | Human food              | Others           | 75        | 25            | 2          | 21           |
| Manure           | Spreading/Compost       | Others           | 0         | 0             | 0          | 0            |
| Meat             | Human food              | Carcass          | 75        | 25            | 4          | 20           |
| Pluck            | Human food              | Others           | 72        | 28            | 4          | 22           |
| Rumen and forestomach | Human food          | Others           | 75        | 25            | 5          | 20           |
| SPA C3           | PAP C3                  | Others           | 99        | 1             | 0          | 1            |
| Screening and sifting wastes | C1-C2 for disposal | Others           | 15        | 85            | 84         | 1            |
| Skin             | Skin tannery C3         | Others           | 68        | 32            | 2          | 30           |
| Sludge           | Spreading/Compost       | Others           | 0         | 0             | 0          | 0            |
| Spleen           | Pet food                | Others           | 75        | 25            | 5          | 20           |
| Sweetbread       | Human food              | Others           | 70        | 30            | 5          | 25           |

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Table 4
Destinations, group of tissues and composition of lamb coproducts (from Gac et al. [2012]).

| Co-products       | Destination       | Group of tissues | Water (%) | DRY MATTER (%) | Lipids (%) | Protéins (%) |
|-------------------|-------------------|------------------|-----------|----------------|------------|--------------|
| Blood             | PAP C3            | Others           | 80        | 20             | 2          | 18           |
| Blood             | Spreading/Compost | Others           | 80        | 20             | 2          | 18           |
| Bones             | PAP C3            | Carcass          | 60        | 40             | 15         | 15           |
| Brain             | Human food        | Others           | 75        | 25             | 10         | 10           |
| Contents of the intestines | Spreading/Compost | Others           | 85        | 15             | 8          | 7            |
| Dead individuals  | C1-C2 for disposal| Others           | 80        | 20             | 4          | 10           |
| Downgraded skin   | PAP C3            | Others           | 68        | 32             | 2          | 30           |
| Fat               | PAP C3            | Carcass          | 10        | 90             | 88         | 2            |
| Floatation fat    | C1-C2 for disposal| Others           | 15        | 85             | 84         | 1            |
| Meat              | Human food        | Carcass          | 76        | 24             | 5          | 20           |
| Other spa c1      | C1-C2 for disposal| Others           | 68        | 32             | 5          | 23           |
| Other spa c3      | PAP C3            | Others           | 68        | 32             | 4          | 25           |
| Pluck (liver, heart, trachea) | Human food | Liver           | 72        | 28             | 4          | 22           |
| Pluck (liver, heart, trachea) | Pet food      | Liver           | 72        | 28             | 4          | 22           |
| Rumen and reticulum | Human food     | GIT              | 75        | 25             | 5          | 20           |
| Sanitary seizures | C1-C2 for disposal| Others           | 67        | 33             | 15         | 17           |
| Screening waste   | C1-C2 for disposal| Others           | 15        | 85             | 84         | 1            |
| Sifting waste     | C1-C2 for disposal| Others           | 15        | 85             | 84         | 1            |
| Skin              | Skin tannery C3   | Others           | 68        | 32             | 2          | 30           |
| Small intestine   | C1-C2 for disposal| GIT              | 75        | 25             | 5          | 20           |
| Small intestine   | Human food        | GIT              | 75        | 25             | 5          | 20           |
| Small intestine   | PAP C3            | GIT              | 75        | 25             | 5          | 20           |
| Stercoral matter  | Spreading/Compost | Others           | 85        | 15             | 8          | 7            |
| Thymus            | Human food        | Others           | 70        | 30             | 5          | 25           |
| Thymus            | Pet food          | Others           | 70        | 30             | 5          | 25           |
| Tongue            | Human food        | Others           | 72        | 28             | 10         | 16           |

To calculate economic allocation factors, an economic dataset has been built by compiling data from ACVIA [7]. The dataset is available respectively for beef, calf and lamb in Tables 10–12.

All these input data are also available in a complete *.csv file (supplementary file 13). This is the formatted database as used by MeatPartTool calculation freeware.

1.2. Allocation factors

For each individual, mass (based on wet mass), economic and biophysical allocation factors are given per kg of coproduct. They are respectively available for bovine, calf and ovine in supplementary file 1, supplementary file 4 and supplementary file 7. Then the total weightings by coproduct (i.e. allocation factor per kg multiplied by the mass of coproduct) are also given (respectively available in supplementary files 2, 5 and 8). Finally, an aggregation by destination category (e.g. Human food, PAP C3, etc.) is also available (respectively in supplementary files 3, 6 and 9).

2. Experimental Design, Materials and Methods

Mass and economic allocation factors have been calculated by following LCA standards. Biophysical allocation factors calculation was performed using Chen et al. (2017) model. A calculation freeware has been developed in Python. The code section that concerns the calculation are given in supplementary files 10, 11 and 12. A specific code is used for each species. These are
Table 5
Carcass Yields and Empty Body Weights at slaughter age for beef (from Laise et al. (2018) and Delomel and Gibon (2019)).

| Breed         | Category     | Carcass Yield | Empty body weight at slaughter age |
|---------------|--------------|---------------|-----------------------------------|
| Limousine     | Heifer       | 0.57          | 633                               |
| Limousine     | Beef         | 0.58          | 755                               |
| Limousine     | Young Bull   | 0.61          | 693                               |
| Limousine     | Cull Cow     | 0.55          | 736                               |
| Salers        | Heifer       | 0.52          | 613                               |
| Salers        | Beef         | 0.53          | 758                               |
| Salers        | Young Bull   | 0.55          | 740                               |
| Salers        | Cull Cow     | 0.5           | 690                               |
| Primholstein  | Heifer       | 0.49          | 586                               |
| Primholstein  | Beef         | 0.51          | 680                               |
| Primholstein  | Young Bull   | 0.52          | 692                               |
| Primholstein  | Cull Cow     | 0.48          | 648                               |
| Rouge des Prés| Heifer       | 0.54          | 639                               |
| Rouge des Prés| Beef         | 0.55          | 758                               |
| Rouge des Prés| Young Bull   | 0.57          | 713                               |
| Rouge des Prés| Cull Cow     | 0.52          | 704                               |
| Blonde d’Aquitaine | Heifer     | 0.59          | 761                               |
| Blonde d’Aquitaine | Beef      | 0.6           | 843                               |
| Blonde d’Aquitaine | Young Bull | 0.63          | 727                               |
| Blonde d’Aquitaine | Cull Cow  | 0.52          | 927                               |
| Charolais     | Heifer       | 0.55          | 718                               |
| Charolais     | Beef         | 0.56          | 839                               |
| Charolais     | Young Bull   | 0.58          | 764                               |
| Charolais     | Cull Cow     | 0.53          | 804                               |
| Charolais x Rustique | Heifer | 0.54          | 639                               |
| Charolais x Rustique | Beef      | 0.55          | 758                               |
| Charolais x Rustique | Young Bull | 0.57          | 713                               |
| Charolais x Rustique | Cull Cow  | 0.52          | 704                               |
| Montbéliarde  | Heifer       | 0.52          | 542                               |
| Montbéliarde  | Beef         | 0.53          | 687                               |
| Montbéliarde  | Young Bull   | 0.55          | 707                               |
| Montbéliarde  | Cull Cow     | 0.5           | 632                               |
| Normande      | Heifer       | 0.52          | 617                               |
| Normande      | Beef         | 0.53          | 743                               |
| Normande      | Young Bull   | 0.55          | 695                               |
| Normande      | Cull Cow     | 0.5           | 698                               |
| Charolais x Pie Noire | Heifer      | 0.52          | 639                               |
| Charolais x Pie Noire | Beef      | 0.54          | 758                               |
| Charolais x Pie Noire | Young Bull | 0.56          | 713                               |
| Charolais x Pie Noire | Cull Cow  | 0.51          | 704                               |
| Average       | Heifer       | 0.54          | 660                               |
| Average       | Beef         | 0.54          | 780                               |
| Average       | Young Bull   | 0.54          | 730                               |
| Average       | Cull Cow     | 0.55          | 742                               |

Python files readable with any code editor (as Notepad++). They work with extra code, formatting a list from a *.csv file. The complete code is implemented in the MeatPartTool open-source freeware [8].

One at a Time sensitivity analysis is provided for the two variant input parameters. The variation of the share of human food destination coproducts is given when testing different Gompertz Coefficients, Carcass Yields and Rearing methods. Results are summed up in Table 13 and more details are provided in Supplementary Files 14. Results are the most sensitive to Gompertz Co-efficient with only 10% of variation between extreme values. Very few information was found about this parameter in the case of the present study. Consequently, the authors think that biophysical allocation would benefit from more research on Gompertz coefficient in the future.
### Table 6
Carcass Yields and Empty Body Weights at slaughter age for calves (from Laisse et al. (2018) and Delomel and Gibon (2019)).

| Breed            | Category      | Carcass Yield | Empty body weight at slaughter age |
|------------------|---------------|---------------|-----------------------------------|
| Limousine        | Milk-fed      | 0.58          | 271                               |
| Limousine        | Rosé          | 0.58          | 236                               |
| Aubrac           | Milk-fed      | 0.58          | 262                               |
| Aubrac           | Rosé          | 0.58          | 229                               |
| Primholstein     | Milk-fed      | 0.58          | 236                               |
| Primholstein     | Rosé          | 0.58          | 206                               |
| Blonde d’Aquitaine | Milk-fed  | 0.58          | 284                               |
| Blonde d’Aquitaine | Rosé    | 0.58          | 248                               |
| Charolais        | Milk-fed      | 0.58          | 252                               |
| Charolais        | Rosé          | 0.58          | 220                               |
| Montbéliarde     | Milk-fed      | 0.58          | 257                               |
| Montbéliarde     | Rosé          | 0.58          | 228                               |
| Normande         | Milk-fed      | 0.58          | 229                               |
| Normande         | Rosé          | 0.58          | 200                               |
| Croisé-lait      | Milk-fed      | 0.58          | 238                               |
| Croisé-viande    | Rosé          | 0.58          | 257                               |
| Average          | Milk-fed      | 0.58          | 252                               |
| Average          | Rosé          | 0.58          | 219                               |

### Table 7
Carcass Yields and Empty Body Weights at slaughter age for lambs (from Laisse et al. (2018) and Delomel and Gibon (2019)).

| Breed            | Category                  | Carcass Yield | Empty body weight at slaughter age |
|------------------|---------------------------|---------------|-----------------------------------|
| Generic          | Milk-fed hardy lamb      | 0.48          | 36                                |
| Generic          | Milk-fed heavy lamb      | 0.48          | 39                                |
| Generic          | Grass-fed heavy lamb     | 0.46          | 41                                |
| Generic          | Milk lamb                | 0.48          | 36                                |
| Generic          | Average                  | 0.475         | 38                                |

### Table 8
Model parameters for beef, calves and lambs.

|                        | Beef            | Calves         | Lambs          |
|------------------------|-----------------|----------------|----------------|
| Gompertz Coefficient   | 0.012           | 0.012          | 0.03           |
| Empty Body Weight at birth | 50              | 50             | 5              |
| Empty Body Weight at maturity | 1000             | 1000           | 65             |
| Birth Body Fat Percentage | 0.06           | 0.06           | 0.1            |
| Normal mature body Fat Percentage | 0.45          | 0.45           | 0.33           |
| Fat percentage at slaughter age | 0.30          | 0.30           | 0.25           |
| Ratio of Body Weight Water to Protein | 3             | 3.5            | 3.5            |
| Protein Energy Content (MJ/kg) | 49.167         | 49.167         | 49.167         |
| Lipid Energy Content (MJ/kg) | 55.352         | 55.352         | 55.352         |

### Table 9
Activity coefficients for beef, calves and lambs.

| Species and calves | Rearing mode | Details                                                                 | Cact     |
|--------------------|--------------|-------------------------------------------------------------------------|----------|
| Beef and calves    | Stall        | Small area (little or no energy)                                        | 0        |
|                    | Pasture      | Sufficient forage (modest energy)                                      | 0.17     |
| Lambs              | Grazing large areas | Open range land or hilly terrain (significant energy)         | 0.36     |
|                    | Housed ewes  | pregnancy in final trimester (50 d)                                   | 0.009    |
|                    | Grazing flat pasture | walk up to 1 km/day and expend very little energy to acquire feed    | 0.0107   |
|                    | Grazing hilly pasture | walk up to 5 km/day and expend significant energy to acquire feed   | 0.024    |
|                    | Housed fattening lambs | animals are housed for fattening                                     | 0.0067   |
| Co-produits                              | Destination          | Group of tissues | Economic value for beef (€/Ton) |
|-----------------------------------------|----------------------|-----------------|---------------------------------|
| Abomasum                                | Human food           | GIT             | 2470                            |
| Abomasum fat                            | Fat and greaves C3   | GIT             | 300                             |
| Aponeurosis                             | Human food           | Carcass         | 3310                            |
| Bile                                    | PAP C3               | Others          | 283                             |
| Blood                                   | PAP C3               | Others          | 736                             |
| Blood                                   | Pet food             | Others          | 242                             |
| Bones                                   | Gelatin C3           | Carcass         | 10                              |
| Bones of head, brain, eyes and teeth    | C1-C2 for disposal   | Others          | 0                               |
| Cheek                                   | Human food           | Others          | 7250                            |
| Cheek                                   | Human food           | Others          | 7250                            |
| Cheek trimmings                         | Pet food             | Others          | 242                             |
| Chops                                   | Pet food             | Others          | 242                             |
| Contents of intestines                  | Spreading/Compost    | GIT             | 0                               |
| Contents of the rumen                   | Spreading/Compost    | GIT             | 0                               |
| Ears                                    | PAP C3               | Others          | 283                             |
| Esophagus                               | Pet food             | Others          | 242                             |
| Fat                                     | Fat and greaves C3   | Carcass         | 300                             |
| Fat around heart                        | Fat and greaves C3   | Others          | 300                             |
| Fat in the kidney                       | Fat and greaves C3   | Others          | 300                             |
| Feet (without hooves)                   | Gelatin C3           | Others          | 10                              |
| Floatation fat                          | Spreading/Compost    | Others          | 0                               |
| Forehead                                | C1-C2 for disposal   | Others          | 0                               |
| Forelock                                | PAP C3               | Others          | 283                             |
| Gallbladder                             | Pet food             | Others          | 242                             |
| Head trimmings                          | Pet food             | Others          | 242                             |
| Heart                                   | Human food           | Others          | 700                             |
| Heart trimmings                         | Pet food             | Others          | 242                             |
| Hide                                    | Skin tannery C3      | Others          | 5500                            |
| Hooves                                  | PAP C3               | Others          | 283                             |
| Horns                                   | PAP C3               | Others          | 283                             |
| Kidney                                  | Human food           | Others          | 1340                            |
| Large intestine                         | C1-C2 for disposal   | GIT             | 0                               |
| Liver                                   | Human food           | Liver           | 1600                            |
| Liver trimmings                         | Pet food             | Liver           | 242                             |
| Lower jaw                               | PAP C3               | Others          | 283                             |
| Lungs                                   | Pet food             | Others          | 242                             |
| Mask                                    | Skin tannery C3      | Others          | 5500                            |
| Mesenteric fat                          | C1-C2 for disposal   | GIT             | 0                               |
| Muscle                                  | Human food           | Carcass         | 5510                            |
| Muzzle                                  | Human food           | Others          | 3310                            |
| Omasum                                  | Human food           | GIT             | 2470                            |
| Omasum fat                              | Fat and greaves C3   | GIT             | 300                             |
| Rumen and forestomach                   | Human food           | GIT             | 2470                            |
| Rumen fat                               | Fat and greaves C3   | GIT             | 300                             |
| Sanitary seizures                       | C1-C2 for disposal   | Others          | 0                               |
| Screening and sifting wastes            | C1-C2 for disposal   | Others          | 0                               |
| Small intestine                         | PAP C3               | GIT             | 200                             |
| Spinal cord                             | C1-C2 for disposal   | Others          | 0                               |
| Spinal cord waste                       | C1-C2 for disposal   | Others          | 0                               |
| Spine                                   | C1-C2 for disposal   | Carcass         | 0                               |
| Spleen                                  | Pet food             | Others          | 242                             |
| Stillborn                               | PAP C3               | GIT             | 0                               |
| Tallow                                  | Fat and greaves C3   | Others          | 300                             |
| Tongue                                  | Human food           | Others          | 5250                            |
| Tonsil                                  | C1-C2 for disposal   | Others          | 0                               |
| Trachea                                 | Pet food             | Others          | 242                             |
| Udder                                   | Pet food             | Others          | 242                             |
| Upper throat                            | Pet food             | Others          | 242                             |
| Water in the rumen                      | Spreading/Compost    | GIT             | 0                               |
### Table 11
Economic value of coproducts for calves in €/ton (from ACYVIA).

| Co-produits                | Destination       | Group of tissues | Economic value for Calves (€/Ton) |
|----------------------------|-------------------|------------------|----------------------------------|
| Dead individuals           | Human food        | GIT              | 200                              |
| Manure                    | Fat and greaves C3| GIT              | 3310                             |
| Screening and sifting wastes | Human food    | Carcass          | 283                              |
| Floatation fat            | PAP C3            | Others           | 0                                |
| Sludge                    | PAP C3            | Others           | 10                               |
| Blood                     | Pet food          | Others           | 0                                |
| Skin                      | Gelatin C3        | Carcass          | 300                              |
| Bile                      | C1-C2 for disposal| Others           | 300                              |
| Spleen                    | Human food        | Others           | 10                               |
| Intestines                | Human food        | Others           | 0                                |
| Fat from breasts and penis | Pet food      | Others           | 7500                             |
| Rumen and forestomach     | Pet food          | Others           | 0                                |
| Abomasum                  | Spreading/Compost | GIT              | 3480                             |
| Sweetbread                | Spreading/Compost | GIT              | 0                                |
| Kidney                    | PAP C3            | Others           | 6840                             |
| Pluck                     | Pet food          | Others           | 1400                             |
| Feet (without hooves)     | Fat and greaves C3| Carcass          | 200                              |
| Head                      | Fat and greaves C3| Others           | 283                              |
| SPA C3                    | Fat and greaves C3| Others           | 0                                |
| Meat                      | Spreading/Compost | Others           | 4000                             |
| Sanitary seizures         | C1-C2 for disposal| Others           | 0                                |
| Other spa c1              | C1-C2 for disposal| Others           | 0                                |
| Other spa c3              | PAP C3            | Others           | 0                                |
| Pluck (liver, heart, trachea) | Human food  | Liver            | 3100                             |
| Pluck (liver, heart, trachea) | Pet food       | Liver            | 3080                             |
| sanitary Seizures         | C1-C2 for disposal| Others           | 0                                |
| Screening Waste           | C1-C2 for disposal| Others           | 0                                |
| Sifting Waste             | C1-C2 for disposal| Others           | 0                                |
| Skin                      | Skin tannery C3   | Others           | 700                              |
| Small Intestine           | C1-C2 for disposal| GIT              | 0                                |
| Small Intestine           | Human food        | GIT              | 0                                |
| Small Intestine           | PAP C3            | GIT              | 0                                |
| Stercoral Matter          | Spreading/Compost | Others           | 0                                |
| Thymus                    | Human food        | Others           | 10,200                           |
| Thymus                    | Pet food          | Others           | 10,200                           |
| Tongue                    | Human food        | Others           | 4500                             |

### Table 12
Economic value of coproducts for lambs in €/ton (from ACYVIA).

| Co-produits                | Destination       | Group of tissues | Economic value for lambs (€/Ton) |
|----------------------------|-------------------|------------------|----------------------------------|
| Blood                     | PAP C3            | Others           | 0                                |
| Blood                     | Spreading/Compost | Others           | 0                                |
| Bones                     | PAP C3            | Carcass          | 0                                |
| Brain                     | Human food        | Others           | 0                                |
| Contents of the intestines| Spreading/Compost | Others           | 0                                |
| Dead individuals           | C1-C2 for disposal| Others           | 0                                |
| Downgraded skin           | PAP C3            | Others           | 0                                |
| Fat                       | PAP C3            | Carcass          | 0                                |
| Floatation fat            | C1-C2 for disposal| Others           | 0                                |
| Meat                      | Human food        | Carcass          | 5300                             |
| Other spa c1              | C1-C2 for disposal| Others           | 0                                |
| Other spa c3              | PAP C3            | Others           | 0                                |
| Pluck (liver, heart, trachea) | Human food  | Liver            | 3100                             |
| Pluck (liver, heart, trachea) | Pet food       | Liver            | 3080                             |
| Rumen and reticulum       | Human food        | GIT              | 0                                |
| Rumen and reticulum       | Pet food          | GIT              | 0                                |
| Sanitary Seizures         | C1-C2 for disposal| Others           | 0                                |
| Screening Waste           | C1-C2 for disposal| Others           | 0                                |
| Sifting Waste             | C1-C2 for disposal| Others           | 0                                |
| Skin                      | Skin tannery C3   | Others           | 700                              |
| Small Intestine           | C1-C2 for disposal| GIT              | 0                                |
| Small Intestine           | Human food        | GIT              | 0                                |
| Small Intestine           | PAP C3            | GIT              | 0                                |
| Stercoral Matter          | Spreading/Compost | Others           | 0                                |
| Thymus                    | Human food        | Others           | 10,200                           |
| Thymus                    | Pet food          | Others           | 10,200                           |
| Tongue                    | Human food        | Others           | 4500                             |
Table 13
Sensitivity analysis of the share of human food destination coproducts depending on main input parameters.

| Input parameter       | Initial value | Tested Values                                                                 | Human Food destination share | Difference between extreme values |
|-----------------------|---------------|--------------------------------------------------------------------------------|-------------------------------|----------------------------------|
| Gompertz Coefficient  | 0.012         | [0.003 ; 0.006 ; 0.009 ; 0.012 ; 0.018 ; 0.024] From 47% to 57%                  |                               | 10%                              |
| Carcass Yield         | 0.56          | [0.50 ; 0.52 ; 0.54 ; 0.56 ; 0.58 ; 0.60] From 48% to 52%                      |                               | 4%                               |

Declaration of Competing Interest

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Supplementary Materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.dib.2020.106558.

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